

CONTRIBUTIONS FROM THE OBSERVATORY OF  
COLUMBIA UNIVERSITY.—No. 16.

JOHN K. REES, Director.

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THE POSITIONS AND PROPER MOTIONS  
OF THE  
PRINCIPAL STARS  
IN THE  
CLUSTER OF COMA BERENICES

AS DEDUCED FROM MEASUREMENTS OF THE RUTHERFURD  
PHOTOGRAPHS.

WALTER C. KRETZ.

Submitted in partial fulfilment of the requirements for the degree of Doctor of  
Philosophy in the Faculty of Pure Science, Columbia University.

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## PREFACE.

The plates discussed by Mr. Kretz were taken by Rutherford with his 13-inch object-glass and correcting lens during the years 1870-1876; three plates in April, 1870; five in June, 1875, and six in May, 1876. These plates were not measured by Rutherford. All the measurements were made on the Repsold Measuring Machine, No. 1, belonging to the Observatory, by Messrs. Kretz, Schlesinger and Hays, who at the time were graduate students in the course upon the "Theory and Methods of Reduction of Photographic Star-Plates" by Professor Jacoby.

The observatory is pleased to acknowledge its obligations to these former students for their efficient and voluntary services.

Rutherford Stuyvesant, Esq., has continued to give generous financial aid for the publication of these results.

JOHN KROM REES,

*Professor of Astronomy*

*and Director of the Observatory,*

*Columbia University.*

NEW YORK CITY,

MARCH 10TH, 1900.

## CONTENTS.

### PART I.—CATALOGUES.

|                              | PAGE. |
|------------------------------|-------|
| I. CATALOGUES AND WEIGHTS.   |       |
| Introduction .....           | 343   |
| List of Catalogues .....     | 344   |
| Weights .....                | 350   |
| II. METHOD OF REDUCTION.     |       |
| Precession .....             | 352   |
| Proper Motion .....          | 354   |
| Systematic Corrections ..... | 357   |
| Formulæ for adjustment ..... | 362   |
| III. TABLES AND RESULTS.     |       |
| Star-Tables .....            | 367   |
| Catalogue of Results .....   | 394   |

### PART II.—PHOTOGRAPHS.

|                                                                                                      |     |
|------------------------------------------------------------------------------------------------------|-----|
| I. THE PLATES: DESCRIPTION AND MEASUREMENT.                                                          |     |
| Description .....                                                                                    | 398 |
| Measurement .....                                                                                    | 400 |
| II. INSTRUMENTAL CORRECTIONS.                                                                        |     |
| Division Errors .....                                                                                | 421 |
| Corrections for Runs and Screw Errors .....                                                          | 422 |
| Measured Coördinates and Rotation Errors .....                                                       | 427 |
| Scale-value Corrections, Projection Errors, and Deviation of the Cylinder<br>from Straightness ..... | 429 |
| III. METHOD OF REDUCTION.                                                                            |     |
| Transformation Corrections .....                                                                     | 438 |
| Refraction Corrections .....                                                                         | 444 |
| Precession, Nutation and Aberration .....                                                            | 448 |
| Constants of the Plates .....                                                                        | 449 |
| IV. RESULTS.                                                                                         |     |
| Constants .....                                                                                      | 456 |
| True Scale-Value .....                                                                               | 459 |
| Separate Results .....                                                                               | 461 |
| Catalogue of Results .....                                                                           | 476 |

## PART I.

### CATALOGUE POSITIONS OF THE STANDARD STARS.

#### I. Catalogues and Weights.

FOR the reduction of stellar photographs it is necessary that the positions of certain stars on the plate be known as accurately as possible. Such stars are designated in the following as standards. When I undertook the measurement and reduction of the Rutherford Photographs of the Cluster in Coma Berenices, the problem arose to determine such standards.

There was no sufficiently accurate set of meridian observations available. Chase's triangulation of the cluster, made at the Yale Observatory, 1891-1892,<sup>1</sup> includes a number of my stars, and these I might have used as standards. But results obtained by the heliometer are not always reliable; that is to say, although the relative positions are in general very accurate, the group as a whole may show a large systematic error. This was to be feared in the present case, as the absolute positions of the stars of the cluster were made to depend ultimately on but two points, determined by meridian observations. Aside from this consideration, Chase gives a very good authority from which to obtain the proper motions of those stars common both to his work and to the Rutherford photographs. Motion of the group as a whole would, however, be eliminated, were his star places

<sup>1</sup> "Triangulation of the Principal Stars of the Cluster in Coma Berenices," by Frederic L. Chase. Transactions of the Astronomical Observatory of Yale University. Referred to as *Chase*.

employed in the reduction of the plate-measurements. I decided, therefore, to obtain the positions of as many stars as possible from all the catalogues available to me, and to use these as standards, that being the method commonly regarded as leading to the most accurate results. How this assumption was borne out in the progress of the work will be shown later (Part II, Sect. IV). The list of catalogues examined includes all that may claim any confidence mentioned in Knobel's memoir,<sup>1</sup> besides all important modern ones, and I have attempted to make it practically complete. Twelve stars were thus found sufficiently well determined to warrant their reduction. One of these was subsequently rejected as standard, the remaining eleven being finally retained. I shall give, however, a record of all observations of stars in my zone which I found in the catalogues.

**List of Catalogues Used.**—Of the catalogues examined, the following contained observations of stars present on the plates :

(1) BRADLEY, 1755. *Neue Reduction des Bradley'schen Beobachtungen aus den Jahren 1750 bis 1762 von Arthur Auwers.* St. Petersburg, 1888.

(2) PIAZZI, 1800. *Præcipuarum Stellarum inerrantium Positiones Mediæ \* \* \* ex observationibus habitis \* \* \* ab anno 1792 ad annum 1813.* Panormi, 1814.

The dates were obtained from the original observations in the *Storia Celeste* ; they are however very doubtful, as in almost every case more observations were found than agreed with the number given in the catalogue, with no way to determine which were excluded from the final reduction. The mean date of all observations was therefore taken ; but in assigning weights the argument used was the number of observations as given in the catalogue.

(3) LALANDE, 1800. *Histoire Céleste Française*, Tome I. Paris, 1801.

Baily's "Lalande," published by the British Association in 1847, was used only as an index to the zone observations, which were re-

<sup>1</sup>Knobel, "The Chronology of Star Catalogues," in *Memoirs of the Royal Ast. Soc.*, Vol. 43, p. I.



duced to 1800 by Von Asten's "Neue Hülftafeln zur Reduction der in der Histoire Céleste enthaltenen Beobachtungen," Vierteljahrsschrift der Astronomischen Gesellschaft, appendix to Vol. 4. Account was taken of the errata published in the introduction to the Paris catalogues, by Peters, and by others.

(4) D'AGELET, 1800. Reduction of the Observations of Fixed Stars made by Joseph Lepaute d'Agelet \* \* \* with a catalogue \* \* \* by B. A. Gould. Washington, 1866.

The mean of the separate observations given in the catalogue was used.

(5) BESSEL, 1825. Astronomische Beobachtungen auf der Königlichen Universitäts-Sternwarte zu Königsberg, for the years 1821 to 1833.

Weisse's Catalogue of Bessel's Northern Zones was used only as index to the original observations, which were reduced anew by the aid of Luther's tables in "Astronomische Beobachtungen auf der Königlichen Universitäts-Sternwarte zu Königsberg," Abt. 37, 2<sup>ter</sup> Teil. An explanation of the necessary formulæ there given, which are similar to those in use with Von Asten's tables, will be found in Argelander's Bonner Beobachtungen, Vol. I, p. xxxvi. Account was taken of the errata to the zones recorded in Part I of the volume containing Luther's paper. The star numbers in the Tables, Sect. III of the present paper, are those of Weisse's catalogue.

(6) STRUVE, 1830. Stellarum Fixarum \* \* \* Positiones Mediæ pro epocha 1830 \* \* \* ex observationibus \* \* \* annis 1822 ad 1843. Petropoli, 1852.

Positions were taken from the "Catalogus Generalis" beginning on page 235, and the mean date was used as there given in column nine, unless a B was found in that column. This means that a certain proper motion, deduced from comparisons with Bradley, was included in the reduction, but as its value is not given, it was deemed best, in such cases, to take the star's position directly from a "Catalogus Specialis" in the preceding part of the volume. Reference to the page will in general be found in column eleven of the "Catalogus Generalis." The "Correctiones Ultimæ" given on pp. 360 ff. were not applied in such cases.

(7) POND, 1830. A Catalogue of 1112 Stars \* \* \* from Observations made at \* \* \* Greenwich from the years 1816 to 1833. London, 1833.

(5)

The mean date of observation is not given in the catalogue. It was obtained from the original records, published in the "Annual Results of Observations at Greenwich." All observations of small stars were made in the years 1830 to 1833 incl. ; those of principal stars in right ascension from 1816 to 1833, and in north polar distance from 1826 to 1833. There are, in general, two observations in N. P. D. for each day, one with each of the two mural circles. For one star (No. 501, decl.), more observations were found in the annual results than are counted in the catalogue ; the same rule with regard to the weight and the mean date was followed in this case as in that of Piazzi.

(8) TAYLOR, 1835. A General Catalogue of the Principal Fixed Stars from Observations made \* \* \* at Madras in the years 1830 to 1843. Madras, 1844.

The mean date is not given. It was obtained from the original records in Vol's 1 to 5 of the Madras observations in a manner similar to that explained by Argelander on pp. 18 and 19 of Vol. VII, Bonner Beobachtungen ; remembering however, that according to the introduction to Vol. 3, the transit instrument was down from 1834 March 6th to 1835 Jan. 31st, and that Taylor was absent in England in the years 1840 and 1841. Account was also taken of the fact that the constellation Coma Berenices comes to the meridian before midnight in the early part of the year. The star numbers as printed in this paper were corrected according to the errata, pp. 6-8, of the catalogue.

(9) RÜMKER, 1836. Mittlere Oerter von 12,000 Fixsternen \* \* \* aus den Beobachtungen auf der Hamburger Sternwarte \* \* \* Hamburg, 1852.

The mean date was taken as 1841, in accordance with the note given by Schorr in his "Bemerkungen zu Carl Rümkers Sterncatalogen," Mittheilungen der Hamburger Sternwarte, No. 3, p. 6.

(10) ROBINSON, 1840. Places of 5,345 Stars observed from 1828 to 1854 at the Armagh Observatory. Dublin, 1859.

The mean date was obtained from the record of the separate observations printed in the first part of the volume.

(11) GILLISS, 1840. Catalogue of 1248 Stars observed at Washington between October, 1838 and July, 1842 \* \* \* Washington, 1846.

The mean date was obtained from the annual results given in the same volume.

(12) PARIS<sub>1</sub>, 1845. Catalogue de l'Observatoire de Paris. Étoiles observées aux Instruments Méridiens de 1837 à 1853. Vol. 3, Paris, 1896.

(13) JACOB, 1850. A Subsidiary Catalogue of 1440 Stars \* \* \* from observations made at Madras in the years 1849-1853. Madras, 1854.

Positions from this catalogue were kindly furnished in manuscript by Prof. Pickering.

(14) WROTTESELEY, 1850. A Catalogue of the Right Ascensions of 1009 Stars; in Mem. Roy. Astr. Society, Vol. XXIII, p. 1. London, 1854.

(15) SIX-YEAR, 1850. Catalogue of 1576 Stars formed from the observations made during Six Years, from 1848 to 1853 at \* \* \* Greenwich. London, 1856.

(16) POULKOVA, 1855. Positions Moyennes déduites des observations faites \* \* \* 1840-1869. Observations de Poulkova, Vol. VIII. St. Pétersbourg, 1889.

The number of observations is not given in the catalogue. It was obtained from the Vols. VI and VII of the "Observations de Poulkova."

(17) ARGELANDER, 1855. Mittlere Oerter von 33,811 Sternen, abgeleitet aus den \* \* \* in den Jahren 1845-1862 angestellten Beobachtungen. Bonn, 1867.

(18) SEVEN-YEAR, 1860. Seven-Year Catalogue of 2,022 Stars deduced from Observations extending from 1854 to 1860 at \* \* \* Greenwich. London, 1864.

(19) PARIS<sub>2</sub>, 1860. Catalogue de l'Observatoire de Paris. Étoiles observées aux Instruments Méridiens de 1854 à 1867. Vol. 3, Paris, 1896.

(20) YARNALL, 1860. Catalogue of Stars observed at the United States Naval Observatory during the years 1845 to 1877. Third edition, revised \* \* \* by Professor Edward Frisby. Washington, 1889.

(21) BRUXELLES, 1865. Catalogue de 10,792 Étoiles observées \* \* \* de 1857 à 1878 \* \* \* par Ernest Quetelet. Bruxelles, 1887.

The catalogue itself does not include positions of the fundamental



stars determined at this observatory. They are given in a separate list on pp. xv ff. of the same volume. None of my stars was found among them.

(22) SAFFORD, 1865. Observations in Right Ascension of 505 Stars, being Vol. IV, Pt. II of the Annals of Harvard College Observatory. Cambridge, 1878.

The positions as used were taken from pp. 30-108, where they are given uncorrected for proper motion, and, in the case of ephemeris stars, with certain periodic terms neglected (cf. *Introd*, p. ix). They are repeated, with these corrections applied, in the General Catalogue on pp. 109-120. In each case, however, the amount of the correction, with its proper sign, is set down in column 9, under the head  $\Delta\alpha$  (*Introd*. p. xv).

(23) NINE-YEAR, 1872. Nine-Year Catalogue of 2,263 Stars deduced from observations extending from 1868 to 1876, made at \* \* \* Greenwich. (No date, Appendix to Observations for 1876.)

(24) DREYER, 1875. Second Armagh Catalogue of 3,300 stars \* \* \* from observations \* \* \* during the years 1859 to 1883 \* \* \* Dublin, 1886.

(25) ROMBERG, 1875. Catalog von 5,634 Sternen aus den Beobachtungen am Pulkowaer Meridiankreise während der Jahre 1874-1880 \* \* \* St. Petersburg, 1891.

(26) PARIS<sub>3</sub>, 1875. Catalogue de l'Observatoire de Paris. Étoiles observées aux Instruments Méridiens de 1868 à 1881. Vol. 3, Paris, 1896.

Catalogues no. (12), (19), and (26) appear as one work of four volumes, each volume embracing six hours of right ascension for all of the three epochs, 1845, '60, and '75. The three corresponding quantities for each star will always be found together on the same line.

(27) ROGERS, 1875. Catalogue of 1213 Stars observed during the years 1870 to 1879, being Vol. XV, Part I of the Annals of the Astronomical Observatory of Harvard College. Cambridge, 1886.

(28) RESPIGHI, 1875. Catalogo delle Declinazioni medie \* \* \* di 1463 Stelle comprese fra i paralleli 20° e 64° nord \* \* \* in Vol. VIII, Ser. 3, Reale Accademia dei Lincei, 1879-80. Roma, 1880.

(29) CATALOG DER ASTRONOMISCHEN GESELLSCHAFT, Zone IX. Catalogue of 14,464 Stars between  $24^{\circ}15'$  and  $30^{\circ}57'$  North Declination, 1855 \* \* \* by A. Graham. Leipzig, 1897.

(30) TEN-YEAR, 1880. Ten-Year Catalogue of 4,059 Stars deduced from observations extending from 1877 to 1886 at \* \* \* Greenwich. London, 1889.

Annual results reduced to the beginning of the year of observation, but as yet uncombined to form larger catalogues, were used in exactly the same manner as were the preceding works. The following series were found to contain observations of my stars.

(31) CAMBRIDGE YEARLY RESULTS, 1836-1869. Astronomical observations made at the Observatory of Cambridge in the years 1836 to 1869.

The stars in these lists are not numbered. The mean date was obtained from the separate results preceding the Catalogue. The same remarks apply to no. (32).

(32) EDINBURGH YEARLY RESULTS, 1840-1886. Astronomical Observations made at the Royal Observatory, Edinburgh, from 1840 to 1886.

Observations were taken at Edinburgh previous to 1840 by Henderson. They were reduced under his direction, while those taken after 1840 were reduced by C. P. Smyth. The earlier set being entitled to higher weight than the latter, I have not grouped them both under one heading. None of my stars was found in the earlier series. The Catalogue compiled from all of these observations by Smyth, under the title "Star Catalogue, Discussion, and Ephemeris from 1830 to 1890" was used only as index to the yearly records.

(33) RADCLIFFE YEARLY RESULTS, 1862-1879. Results of Astronomical Observations made at the Radcliffe Observatory in the years 1862 to 1879.

No observations of stars were made in 1877, '78, and '79.

(34) MADRAS YEARLY RESULTS, 1862-1882. Results of Observations of the fixed stars made at Madras in the years 1862 to 1882 inclusive, under the direction of N. R. Pogson.

(35) GREENWICH YEARLY RESULTS, 1887 to 1894. Results of the Astronomical Observations made at the Royal Observatory, Greenwich, in the years 1887 to 1894.

The Greenwich Five-Year Catalogue includes some of these observations ; but the greater part of them are not as yet combined. Such of my stars as were found in this series were of the latter number.

**Weights :** On the preceding pages I have detailed the catalogues used in the present paper. The observations are, of course, not all of the same standard of excellence. Weights were assigned depending approximately on the probable error of a position as given in a catalogue, the probable error of an observation of unit weight being taken arbitrarily as  $0''.4$  of arc of a great circle. A table of weights was constructed on this basis by Dr. Davis when engaged in a research similar to the present one, and is printed in his memoir on the subject.<sup>1</sup> To it I refer. It must be remembered, however, in regard to the Annual Results, that I have regarded the observations of each year as forming a separate catalogue, and have weighted them as such, whereas Dr. Davis first reduced them all to 1875, and then assigned a weight to the mean depending on the total number of observations taken at the observatory in question. In all other respects the table was used exactly as there explained.

A few of the catalogues used by me are not included in this list. They follow, together with the number of the star or stars, the corresponding number of observations, and the assigned weight. The figures in brackets refer to the preceding list of catalogues.

(11) GILLISS, 1840. Star no. 605, 1 obs., wt. = 0.1.

Star no. 608, 13 obs., wt. = 1.0. ♀

(14) WROTTESELEY, 1850. Star no. 447, 5 obs., wt. = 0.5.

(22) SAFFORD, 1865. Star no. 194, 7 obs., wt. = 2.0.

Star no. 195, 6 obs., wt. = 2.0.

<sup>1</sup> "Declinations and Proper Motions of Fifty-Six Stars," by Herman S. Davis, Ph.D. Memoir I, of the N. Y. Academy of Sciences. Referred to as *Davis*. The table of weights will be found on pp. 14 to 18.



For (17) ARGELANDER, 1855, the same weights were used as are given for Oeltzen-Argelander in *Davis*.

The same table was assumed to apply to both right ascensions and declinations. This has been the generally accepted method: but my results indicate that it is not always correct. On the whole, the residuals are larger in right ascension than in declination. Especially is this the case with the older catalogues. I have compared the probable errors in the two coördinates obtained from the eight published zones of the A. G. C. (that being my standard of weight) and find a difference, which, though slight, is in the direction mentioned. A separate table of weights to be used for right ascensions would therefore be desirable. For my purpose, I have not deemed the additional accuracy obtained thereby sufficient to compensate for the labor involved.

## II. Method of Reduction.

**Precession.**—The epoch selected was 1875, that being very near the mean of the dates at which the plates were taken. The precession factors were computed by Professor Hill's formulæ as given in the "*Star Tables of the American Ephemeris*," Wash., 1869, pp. xviii, xix. The constants used were those of Peters and Struve, being, for 1800

$$m = 3^s .07082 + ^s.000 01899t$$

$$n = 20''.0607 - '' .000 0863t.$$

Introducing these values in Hill's formulæ, we obtain for 1875, the numbers in brackets denoting logarithms :

$$\frac{da}{dt} = 3^s.07225 + [0.126115] \sin a \tan \delta + \mu$$

$$\frac{d\delta}{dt} = [1.302206] \cos a + \mu'$$

$$\begin{aligned} \frac{d^2a}{dt^2} &= [4.63380_n - 10] \left( \frac{da}{dt} - \mu \right) \\ &+ [5.98778 - 10] \left( \frac{da}{dt} + \mu \right) \cos a \tan \delta \\ &+ [4.81169 - 10] \left( \frac{d\delta}{dt} + \mu' \right) \sin a \sec^2 \delta \\ &+ [4.9866 - 10] \mu \mu' \tan \delta \\ &+ 0.^s.000 032 210 \end{aligned}$$

$$\begin{aligned} \frac{d^2\delta}{dt^2} &= [4.63380_n - 10] \left( \frac{d\delta}{dt} - \mu' \right) \\ &+ [7.16387_n - 10] \left( \frac{da}{dt} + \mu \right) \sin a \\ &+ [6.7367_n - 10] \mu^2 \sin 2\delta. \end{aligned}$$

The third term, both in right ascension and in declination, was taken from Klock's "*Tafeln der Praecession*," that being

sufficiently accurate on account of the small value of the proper motion for all of my stars.

In the above formulæ,  $\alpha$ ,  $\mu$ ,  $\delta$  and  $\mu'$  denote respectively the right ascension and corresponding proper motion and the declination and corresponding proper motion for 1875. In calculating the constants, the right ascensions and declinations were taken uniformly from the *Astronomische Gesellschaft Catalog*, Zone IX; the proper motions either from Auwers' "*Neue Reduction der Bradley'schen Beobachtungen*" or from Safford's "*Catalogue of Mean Declination of 2,018 Stars*."

If now we put

$$J = \frac{da}{dt}, \quad K = \frac{d^2a}{dt^2} \times 10^2, \quad P = \frac{d^3a}{dt^3} \times \frac{1}{6} \times 10^6$$

$$L = \frac{d\delta}{dt}, \quad M = \frac{d^2\delta}{dt^2} \times 10^2, \quad N = \frac{d^3\delta}{dt^3} \times \frac{1}{6} \times 10^6$$

and let

$T$  = the epoch of any catalogue, and

$\alpha_T, \delta_T$  = the right ascension and declination as there given, then will

$$\alpha_{1875} = \alpha_T + J(1875 - T) + K \frac{(1875 - T)^2}{200} + P \left( \frac{1875 - T}{100} \right)^3$$

$$\delta_{1875} = \delta_T + L(1875 - T) + M \frac{(1875 - T)^2}{200} + N \left( \frac{1875 - T}{100} \right)^3$$

as is evident at once when we remember that the above expressions are the first few terms of the expansion by Taylor's formula of  $\alpha$  and  $\delta$ , thus

$$\alpha = \alpha_0 + \left( \frac{da}{dt} \right) t + \frac{1}{2} \left( \frac{d^2a}{dt^2} \right) t^2 + \frac{1}{6} \left( \frac{d^3a}{dt^3} \right) t^3 + \dots$$

and similarly for  $\delta$ . Here  $\alpha_0$  is the right ascension at the epoch for which the precession is to be computed, 1875 in the present case, and  $t$  is the interval from this epoch to the epoch of  $\alpha$ . For dates later than 1875,  $t$  is plus; for those earlier, it is minus. Hence, transposing  $\alpha_0$  to the first, and  $\alpha$  to the second member, changing the signs and introducing the previous notation, we obtain the series in the form given above.



The coefficients of  $J$ ,  $K$  and  $P$ , denoted respectively by  $U$ ,  $V$ , and  $W$ , depend only on the time, and may be tabulated. This is here done for the epochs used by me. Signs at the top are for the dates at the left of the table; signs at the bottom are for dates at the right.

| Epoch. | $U$ | $V$    | $W$   |        | Epoch. | $U$ | $V$   | $W$   |        |
|--------|-----|--------|-------|--------|--------|-----|-------|-------|--------|
|        | +   | —      | +     |        |        | +   | —     | +     |        |
| 1755   | 120 | 72.000 | 1.728 |        | 1860   | 15  | 1.125 | 0.003 | 1890   |
| 1800   | 75  | 28.125 | 0.422 |        | 61     | 14  | 0.980 | 0.003 | 89     |
| 24     | 51  | 13.005 | 0.133 |        | 62     | 13  | 0.845 | 0.002 | 88     |
| 25     | 50  | 12.500 | 0.125 |        | 63     | 12  | 0.720 | 0.002 | 87     |
| 30     | 45  | 10.125 | 0.091 |        | 64     | 11  | 0.605 | 0.001 | 86     |
| 1835   | 40  | 8.000  | 0.064 |        | 1865   | 10  | 0.500 | 0.001 | 1885   |
| 36     | 39  | 7.605  | 0.059 |        | 66     | 9   | 0.405 | 0.001 | 84     |
| 40     | 35  | 6.125  | 0.043 |        | 67     | 8   | 0.320 | 0.001 | 83     |
| 42     | 33  | 5.445  | 0.036 |        | 68     | 7   | 0.245 | 0.000 | 82     |
| 43     | 32  | 5.120  | 0.033 |        | 69     | 6   | 0.180 |       | 81     |
| 1844   | 31  | 4.805  | 0.030 |        | 1870   | 5   | 0.125 |       | 1880   |
| 45     | 30  | 4.500  | 0.027 |        | 71     | 4   | 0.080 |       | 79     |
| 47     | 28  | 3.920  | 0.022 |        | 72     | 3   | 0.045 |       | 78     |
| 50     | 25  | 3.125  | 0.016 | 1900   | 73     | 2   | 0.020 |       | 77     |
| 55     | 20  | 2.000  | 0.008 | 1895   | 74     | 1   | 0.005 |       | 76     |
| 1856   | 19  | 1.805  | 0.007 | 1894   | 1875   | 0   | 0.000 |       | 1875   |
| 58     | 17  | 1.445  | 0.005 | 92     |        |     |       |       |        |
| 59     | 16  | 1.280  | 0.004 | 91     |        |     |       |       |        |
| —      | —   | —      | —     | Epoch. | —      | —   | —     | —     | Epoch. |

**Proper Motion.**—Some catalogues take account of the proper motion in reducing from apparent to mean place. As its value, however, in general differs from that assumed in the present paper, a correction to eliminate its effect must be introduced.  $\mu$  being the proper motion as assumed by me,  $\mu'$  that used in the catalogue under consideration, and  $T$  and  $t$ , as usual, the epoch of reduction and the epoch of the catalogue respectively, we have

$$\text{Correction for erroneous } pm = (T - t)(\mu - \mu'),$$

which becomes, for  $\mu' = 0$

$$(T - t)\mu.$$

It is not always plain whether a certain catalogue uses proper motion in the reduction to mean place or not. I subjoin

the conclusion at which I arrived in each special case, and in accordance with which the correction was applied in the succeeding calculations. The numbers refer to the catalogues detailed in Sec. I.

(1) The proper motion given is used in the reduction. See pp. 18 and 20 of the introduction.

(2), (3), (4), (5) These do not take account of proper motion. In (3) and (5) it is not mentioned; in the case of (4) see *Introd.*, p. 26, § 11; and for (2) see Argelander's *Bonner Beobachtungen*, Vol. VII, p. 10.

(6) No proper motion is applied unless a  $B$  is found in the column headed "Epocha Media." Its value, although not given, may be obtained from the value for Str.—Bradley, given pp. 299 ff. See *Introd.*, p. LXXX.

(7) Pond uses the A. S. C. constants and no proper motion unless therein included. Such cases are marked by an asterisk in the column of precessions, the same as in the volumes from which the constants are copied.

(8) Proper motions greater than  $0''.5$  are always, and those greater than  $0''.25$  are sometimes included in the reduction. Smaller values are always neglected. *Introd.*, p. 2.

(9) No statement. Proper motion is probably not taken into account.

(10) According to *Introd.*, p. xxviii, proper motion is not used in the reductions.

(11) Proper motion is neglected in reducing the observations to the beginning of the year, except where included in the A. S. C. constants (*Introd.*, p. xxiv); but in combining the separate annual results into a general catalogue, it is taken into account (p. 595, "Column 6") whenever its value is given.

(12) See (26).

(13) This catalogue does not take account of proper motion. As it was not accessible to me, I could not personally verify the above statement, which is made in accordance with *Davis*, p. 28, no. 69.

(14) I could not find any definite statement bearing on

the point in question. It seems, however, that proper motion is not used. Cf. *Introd.*, pp. 15-17.

(15) The same notes apply to this catalogue as to no. (11), except in the case of N. A. stars, when the proper motion is taken into account. See *Introd.*, p. iv; also *Twelve-Year Catalogue*, pp. vii and ix, and *Seven-Year Catalogue* for 1860, pp. {vi} and {x}, and Appendix.

(16) No statement is made in the introduction to Vol. VIII of the "Observations de Poulkova," which contains the catalogue. Backlund, however, in an article designed originally to form the preface to the catalogue, but afterwards published in the *Memoirs of the St. Petersburg Imperial Academy*, states, that proper motion was used when given either by Auwers in his "*Bradley*" or by Argelander in his "*250 Stars with Proper Motions*." Backlund superintended most of the computations. *Loc. cit.*, Vol. 34, no. 7, p. 4.

(17) Proper motion seems to be neglected. No mention of this matter is made in the introduction.

(18) Proper motion is used in the reductions. See *Introduction*, pp. {vi} and {x}.

(19) See (26).

(20), (21) Both catalogues neglect proper motion. See (20) *Introd.*, p. xxiv; (21) *Introd.*, p. xii.

(22) See the remarks on this catalogue in Sec. I of the present paper.

(23) Proper motion is used. See *Introd.*, p. 4.

(24) This catalogue does not take account of proper motion. Cf. *Introd.*, p. ix.

(25) The proper motion as given is included in the reductions. See *Introd.*, p. (12).

(26), (12), and (19) According to p. [2] of Vol. I, proper motion is always neglected.

(27) Account is taken of the proper motion whenever given. *Introd.*, p. vi.

(28) Proper motion is included in the annual variation for each star given in this catalogue. Its value, although not set down, may be obtained by subtracting the corresponding

geometric precession from that quantity. The original authority for the proper motions of all others than fundamental stars is the B. A. C. See p. 134.

(29) Proper motion is not used.

(30) As in the other Greenwich catalogues, proper motion is employed in the reductions. See Introd., p. 4.

In the case of the Annual Results, proper motion has a very slight effect as it is always used for a fraction of a year only, and is therefore rather unimportant. I found, however, the following :

(31) The Cambridge Annuals. Proper motion is not taken into account, except for Nautical Almanac Stars when included in the annual variations there given.

(32) The Edinburgh Annuals, up to the publication of the B. A. C. in the year 1845, were reduced by means of the A. S. C. and Nautical Almanac constants, using proper motion only if therein included. After that, however, the B. A. C. values, both of precession and proper motion, were always used, if possible, for stars not given in the N. A.

(33) The Radcliffe Annuals do not use proper motion. For Nautical Almanac Stars it is, however, generally included in the precessions ; these are marked with an asterisk in such cases.

(34) The Madras Annuals do not use proper motion.

(35) The Greenwich Annuals employ proper motion in the reduction to mean place.

**Systematic Corrections.**—The system used throughout was that of the "*Fundamental-Catalog der Astronomischen Gesellschaft*." Corrections to reduce the catalogue positions to this standard are given by Auwers in the *Astronomische Nachrichten* nos. 3195-96, and 3413-14. A number of lists of stars, notably annual results, are not mentioned in these papers, however. For such cases it was generally possible to obtain values of the corrections to the declinations from Boss, "*Report on the Declination of Stars, etc.*," pp. 579 ff. They were reduced from his "mean system" to the A. G. C. system by the aid of the



formulæ and table following, which I reproduce from Dr. Davis' memoir :

To Boss' value add the quantity

$$m + K (T - 1883) \text{ when } T < 1866$$

or

$$m + K' (T - 1883) \text{ when } T > 1866.$$

Here

$$m = \text{A. G. C.} - \text{Boss (good for 1883)}$$

and is obtained from the Berlin Jahrbuch, 1884, Appendix.  $K$  and  $K'$  are the annual variations of  $m$  computed as shown in the table, p. 359, in which we assume  $\Delta\delta_a = 0$ .

There still remained a number of cases to be treated, however, chiefly right ascensions, for Boss gives corrections to the declinations only. For all of these I deduced corrections by direct comparison with some suitable catalogue whose system was well known. The labor was greatly simplified by the fact, that no account had to be taken of change in right ascension or in declination, as my stars are all situated within a few degrees of each other. The rule laid down was to compare as many stars as possible (usually about 12) within not more than one hour in right ascension, and five degrees in declination on either side of the center of my plate. Systematic corrections were thus deduced for the following catalogues :

*Bessel* ((5) of Sect. I), *Zones 464 and 503*.—Auwers, in his zone of the A. G. C., gives corrections to all those of Bessel's zones which fall within the limits of his catalogue. He shows that they consist of two parts, a systematic one, depending on the constants used in the reductions, and one due purely to accidental causes. Luther's tables fail to eliminate the latter class. Without attempting to distinguish between them, I deduced the total amount by direct comparison with the A. G. C., correcting for proper motion whenever that was possible. I find thus :

$$\text{A. G. C.} - \text{Bessel, Zone 464 (in } \alpha) = + 0''.190$$

$$\text{“ “ “ “ (in } \delta) = - 3''.60$$

$$\text{A. G. C.} - \text{Bessel, Zone 503 (in } \alpha) = + 0''.122$$

$$\text{“ “ “ “ (in } \delta) = + 3''.15$$

TABLE.

| $\delta$ | A. G. C.—Boss<br>for |                 |             |           |                   | A. G. C.—Boss<br>for  |                       | ANNUAL VARIATION. |         |                      |                       |
|----------|----------------------|-----------------|-------------|-----------|-------------------|-----------------------|-----------------------|-------------------|---------|----------------------|-----------------------|
|          | Groom.<br>1810       | Struve.<br>1830 | Abo<br>1830 | 1823<br>a | Mean<br>1830<br>b | Poulkova<br>1855<br>c | (Auwers)<br>1883<br>m | NOTE I.           | NOTE 2. | 1810 to<br>1865<br>K | 1866 to<br>1883<br>K' |
|          |                      |                 |             |           |                   |                       |                       |                   |         |                      |                       |
| 65°      | +.38                 | +.28            | +.25        | +.30      | +.30              | +.21                  | +.03                  | — .0045           | — .0011 | — .0028              | — .0064               |
| 60       | +.18                 | +.18            | +.18        | +.18      | +.18              | +.15                  | +.04                  | — .0023           | — .0050 | — .0001              | — .0039               |
| 55       | +.06                 | +.06            | +.06        | +.06      | +.06              | +.01                  | +.06                  | +.0000            | +.0050  | +.0025               | +.0018                |
| 50       | +.09                 | — .14           | — .08       | — .04     | — .04             | — .05                 | +.11                  | +.0025            | +.0053  | +.0039               | +.0057                |
| 45       | +.01                 | — .29           | — .23       | — .17     | — .17             | — .02                 | +.15                  | +.0053            | +.0053  | +.0053               | +.0061                |
| 40       | [— .50]              | — .54           | — .52       | — .52     | — .53             | — .19                 | +.15                  | +.0128            | +       | +.0121               | +.0121                |
| 35       |                      | — .72           | — .69       | — .71     | — .71             | — .26                 | +.14                  | +.0160            | +.0174  | +.0167               | +.0143                |
| 30       |                      | — .84           | — .76       | — .80     | — .80             | — .19                 | +.09                  | +.0168            | +       | +.0157               | +.0100                |
| 25       |                      | — .95           | — .81       | — .88     | — .88             | — .13                 | +.01                  | +.0168            | +.0116  | +.0142               | +.0050                |
| 20       |                      | — 1.01          | — .92       | — .97     | — .97             | — .07                 | +.06                  | +.0173            | +.0126  | +.0147               | +.0004                |
| 15       |                      | — 0.95          | — .83       | — .89     | — .89             | — .02                 | +.10                  | +.0149            | +       | +.0138               | — .0029               |

NOTE 1.—This column gives  $\frac{a-m}{1823-1883}$  or  $\frac{b-m}{1830-1883}$  as the case may be.

NOTE 2.—This is an approximate annual variation deduced by direct comparison of the proper motions of Boss and AUWERS by Professor T. H. Safford.

$K$  is the mean of the two preceding columns and  $K' = \frac{c-m}{1855-1883}$ .

*Cambridge Annals* (31).—Observations in right ascension of my stars were taken in the years 1842, '44, '45 and '47. Corrections to the years 1842 and 1845 were obtained by direct comparison with Struve's "Positiones Mediae." During 1844 and 1847 not enough stars were observed in the zone selected by me to warrant a comparison with Struve. For 1844 I accordingly assumed the same corrections as for 1845, and for 1847, zero was used, as no other value was procurable. Corrections to the declinations are given by Boss. My investigations give, for the right ascensions :

$$\text{A. G. C.} - \text{Cambridge 1842} = - 0^s.075$$

$$\text{A. G. C.} - \text{Cambridge 1845} = + 0^s.147$$

*Edinburgh Annals* (32).—Boss, who gives corrections to the declinations, divides this series into several groups, of which the following include the dates of observation of my stars : 1854–1860, 1861–1864, 1865–1869. Corrections were computed by comparison with the A. G. C. for the years 1856, 1864, and 1868, being one year in each group. Two stars were observed in 1842, and for this year a correction was deduced by comparison with the new Seven-Year Catalogue. The reductions were always made including proper motion if possible. The values found were as follows :

$$\text{A. G. C.} - \text{Edinb. 1842} = - 0^s.012$$

$$\text{A. G. C.} - \text{Edinb. 1856} = - 0^s.087$$

$$\text{A. G. C.} - \text{Edinb. 1864} = - 0^s.070$$

$$\text{A. G. C.} - \text{Edinb. 1868} = - 0^s.042$$

*Radcliffe Annals* (33).—Corrections to the declinations observed before 1874 are given by Boss. One of my stars was found in the volume for 1874. The correction in this case was calculated by extrapolation from 1872 and 1873. For the right ascensions the usual method was followed, comparisons being made both with the A. G. C. and with the Paris 1875. Corrections to the observations of the years 1868, 1870 and 1871 were thus obtained. In the year 1873 not sufficient stars were observed to make a satisfactory comparison possible. For

this case, zero was therefore assumed. The results reached were as follows :

$$\text{A. G. C.—Radcliffe 1868} = + 0^s.033$$

$$\text{A. G. C.—Radcliffe 1870} = - 0^s.071$$

$$\text{A. G. C.—Radcliffe 1871} = - 0^s.020$$

*Greenwich Annals* (35).—The same systematic corrections were used as are given by Auwers for the Ten-Year Catalogue. See *Davis*, p. 24, no. 40.

A few of the catalogues deserve special notice in this connection. They are :

(1) *Auwers-Bradley*.—No systematic corrections to this catalogue have been published by the author, which indicates that their value is zero. I have so assumed it for the two stars found in this list.

(4) *d'Agelet*.—Auwers gives systematic corrections to this catalogue on p. 60 of his zone of the A. G. C., but applying only within the limits of that zone. On page 30 of the introduction, Gould himself gives the result of a comparison with Piazzì. His terms are not quite clear, however. He gives corrections for what he calls the first and second group, without stating where the dividing line between the groups is situated. I have assumed it to be at 12<sup>h</sup> in accordance with a statement at the bottom of page 29, and find thus

$$\text{Piazzì—d'Agelet in } \alpha = + 0^s.079$$

$$\text{Piazzì—d'Agelet in } \delta = + 1''.22,$$

whence (A. G. C.—d'Agelet) is easily obtained.

(6) *Struve*.—The same correction was assumed to apply to the "Catalogus Specialis" for 1824 as to the "Catalogus Generalis" for 1830.

(17) *Argelander*.—In accordance with pp. vi and ix of the introduction, the corrections of the Abo Catalogue reduced to 1855, as given by Auwers, were applied to my stars found in this catalogue.

(12), (19), and (26) *Paris*.—The corrections given by Auwers for the first twelve hours of right ascension were assumed to apply equally to the third quadrant.



(20) *Yarnall*.—Corrections to this catalogue will be found in both of Auwers' papers. The second set was used by me.

**Formulæ for Adjustment.**—The usual methods of least-square solution with artifices of computation analogous to those published in *Davis*, pages 11 and 12, were employed. I shall deduce the formulæ for right ascension only; the discussion for the other coördinate is entirely similar.

If we let

$B_i$  = the seconds of an observed right ascension reduced to 1875, using an assumed value for the proper motion, and corrected for systematic errors;

$t_i$  = the date of observing  $B_i$ ;

$a_0$  = the seconds of the right ascension to be obtained from the observations, corresponding to some fixed epoch  $T_0$ ;

$\Delta\mu_0$  = the correction to be subtracted from the assumed proper motion;

then evidently we should have

$$a_0 - \{B_i + \Delta\mu_0 (t_i - T_0)\} = 0; \quad (1)$$

or, if the weight of  $B_i$  be  $p_i$ ,

$$\sqrt{p_i} a_0 - \sqrt{p_i} \Delta\mu_0 (t_i - T_0) - \sqrt{p_i} B_i = 0. \quad (1a)$$

Writing, then,  $m$  equations of condition of the above form, one for each observed  $B_i$ , and solving by least squares, we get the following normals, where the square brackets as usual denote summation:

$$\left. \begin{aligned} [p] a_0 - [p(t - T_0)] \Delta\mu_0 - [pB] &= 0 \\ -[p(t - T_0)] a_0 + [p(t - T_0)^2] \Delta\mu_0 + [pB(t - T_0)] &= 0. \end{aligned} \right\} \quad (2)$$

By suitably selecting the epoch  $T_0$  we can greatly facilitate the succeeding work—an artifice first employed for this kind of work by Professor Safford.<sup>1</sup> For let us take  $T_0$  as the mean of all the dates  $t$ , that is, let

$$T_0 = \frac{[pt]}{[p]},$$

<sup>1</sup> See Safford, "Catalogue of 2018 Stars," *Introd.*, p. 12.

then will

$$[\dot{p}(t - T_0)] = 0,$$

and equations (2) become

$$\left. \begin{aligned} [\dot{p}] a_0 - [\dot{p}B] &= 0 \\ [\dot{p}(t - T_0)^2] \Delta\mu_0 + [\dot{p}B(t - T_0)] &= 0, \end{aligned} \right\} \quad (3)$$

whence at once

$$\left. \begin{aligned} a_0 &= \frac{[\dot{p}B]}{[\dot{p}]} \text{ with the weight } [\dot{p}] \\ \Delta\mu_0 &= -\frac{[\dot{p}B(t - T_0)]}{[\dot{p}(t - T_0)^2]} \text{ with the weight } [\dot{p}(t - T_0)^2]. \end{aligned} \right\} \quad (4)$$

If now we write

$$\begin{aligned} (t - T_0) &= C, & \dot{p}(t - T_0) &= D, \\ a_0 - B &= E, \end{aligned}$$

and remember that

$$[\dot{p}C(a_0 - B)] = a_0[\dot{p}C] - [\dot{p}CB] = -[\dot{p}(t - T_0)B]$$

since

$$[\dot{p}C] = 0,$$

we get finally the formulæ

$$\left. \begin{aligned} a_0 &= \frac{[\dot{p}B]}{[\dot{p}]} \\ \Delta\mu_0 &= \frac{[DE]}{[CD]}. \end{aligned} \right\} \quad (5)$$

The probable error of an observation  $B$  whose weight is unity is, by the usual formula

$$r_1 = \pm .6745 \sqrt{\frac{[vv]}{m-2}},$$

the  $v$ 's being the residuals obtained by substituting the final values of  $a_0$  and  $\Delta\mu_0$  in equation (1). Hence the probable error of

$$\left. \begin{aligned} a_0 \text{ at the epoch } T_0 &= \frac{r_1}{\sqrt{[\dot{p}]} } = r_T \\ \Delta\mu_0 &= \frac{r_1}{\sqrt{[CD]}} = r_\mu \\ a_0 \text{ reduced to 1875 using } \Delta\mu_0 &= \sqrt{r_T^2 + \{(1875 - T_0) r_\mu\}^2} = r_{1875}. \end{aligned} \right\} \quad (6)$$

(23)

As  $\Delta\mu_0$  and  $a_0$  are not independently determined the correctness of the last formula is not immediately evident. It is, however, easily proved. For we have

$$\begin{aligned}
 a_{1875} &= a_0 + (1875 - T_0) \Delta\mu_0 \\
 &= \frac{[pB]}{[p]} - (1875 - T_0) \frac{[pCB]}{[CD]} && [\text{by equation (4)}] \\
 &= \frac{p_1 B_1 + p_2 B_2 + \dots + p_m B_m}{[p]} \\
 &\quad - (1875 - T_0) \frac{p_1 C_1 B_1 + p_2 C_2 B_2 + \dots + p_m C_m B_m}{[CD]} \\
 &= \frac{1}{[p][CD]} \left\{ p_1 B_1 ([CD] - (1875 - T_0)[p] C_1) \right. \\
 &\quad \left. + p_2 B_2 ([CD] - (1875 - T_0)[p] C_2) \right. \\
 &\quad \left. + \dots \dots \dots \right\}
 \end{aligned}$$

and since the  $B$ 's are independent, and the probable error of  $B_i$  is  $r_1 / \sqrt{p_i}$ , we get for the probable error of  $a_{1875}$

$$\begin{aligned}
 r_{1875}^2 &= \frac{1}{[p]^2 [CD]^2} \left\{ p_1 r_1^2 ([CD] - (1875 - T_0)[p] C_1)^2 \right. \\
 &\quad \left. + p_2 r_2^2 ([CD] - (1875 - T_0)[p] C_2)^2 \right. \\
 &\quad \left. + \dots \dots \dots \right\} \\
 &= \frac{r_1^2}{[p]^2 [CD]^2} \left\{ [p][CD]^2 - 2[CD][p](1875 - T_0)[pC] \right. \\
 &\quad \left. + [p]^2 [pC^2] (1875 - T_0)^2 \right\} \\
 &= \frac{r_1^2}{[p]} + (1875 - T_0)^2 \frac{r_1^2}{[CD]} \\
 &= r_T^2 + (1875 - T_0)^2 r_\mu^2
 \end{aligned}$$

remembering that

$$[pC] = 0 \text{ and } [pC^2] = [CD].$$

In applying the above formulæ to a special case, I invariably proceeded as follows (the explanation is again confined to right ascension; it applies equally to declination, however):

Calculate the sums

$$\Sigma(pB), \quad \Sigma(pt), \quad \Sigma(p).$$

Then

$$a_0 = \frac{\Sigma(pB)}{\Sigma(p)} - \beta, \quad T_0 = \frac{\Sigma(pt)}{\Sigma(p)} - \beta',$$

$\beta$  and  $\beta'$  being the remainders. Now form for each catalogue position the quantities

$$(t - T_0) = C, \quad p(t - T_0) = D, \quad (a_0 - B) = E.$$

The computations up to this point will all be checked,<sup>1</sup> when

$$\Sigma p(a_0 - B) = -\beta, \quad \Sigma p(t - T_0) = +\beta'.$$

From the expressions last obtained we easily get

$$\Sigma(DE) \text{ and } \Sigma(CD)$$

which we check<sup>1</sup> by the equations

$$\begin{aligned} \Sigma(DE) &= \Sigma(pE \cdot C) \\ \Sigma(CD) &= \Sigma(pC^2). \end{aligned}$$

Then

$$\Delta\mu_0 = \frac{\Sigma(ED)}{\Sigma(CD)}$$

and

$$\mu_0 = \mu - \Delta\mu_0,$$

$\mu$  being the previously assumed proper motion. Also

$$a_{1875} = a_0 - \Delta\mu_0 (1875 - T_0).$$

To obtain the probable errors, I did not, however, employ formulæ (6) as they stand. For thereby the weight of each star is placed on an independent basis, and the probable errors form no means whereby to judge of the relative accuracy of the final positions. For the factor  $r_1$  is not the same for all the stars, depending, as it does, on the accidental error in each catalogue as shown by the residual. We must seek a value for  $r_1$ , which will satisfy all the observations taken of all the stars, not of one star only. Such a value is furnished by the statement in Sec. I, "WEIGHTS," which reads, that the probable error of an observation of unit weight was arbitrarily assumed as  $0''.4$

<sup>1</sup> As suggested in *Davis*, page 11.

of arc of a great circle. If then we change formulæ (6) to read

$$r_T = \frac{0''.4}{\sqrt{[p]}}, \quad r_\mu = \frac{0''.4}{\sqrt{[CD]}}$$

and, as before

$$r_{1875} = \sqrt{r_T^2 + \{ (1875 - T_0) r_\mu \}^2},$$

we obtain probable errors which make a direct comparison possible, and which enable us to assign relative weights to the resulting positions for 1875. This is what I have done throughout, and all probable errors are computed by the above expressions. It should be mentioned here, however, that, for right ascensions, the values obtained by the above formulæ must be multiplied by  $\sec \delta$ , in order to make them applicable to the position of the star; for evidently the formulæ give the probable error in equatorial seconds for both coördinates. This I have done for all of my stars, and the probable errors in right ascension found in the succeeding tables are therefore in terms of seconds of arc of a small circle of declination passing through the star in question.



### III. Tables and Results.

**Star-Tables.**—On the following pages are recorded the data from which the final positions were obtained, together with the most important part of the calculations. The tables, when taken in connection with the preceding sections, require little comment. A few points may be mentioned, however.

The caption gives the Bonn Durchmusterung number, the usual designation of a star, and Chase's number; also the precession constants, together with the right ascension and declination for 1875, and the respective assumed proper motions used in calculating the same.

Columns 1, 2, 3, 4, 5, 6 and 12 require no explanation. They refer to matters treated in Sect. I of this paper.

Columns 7 to 11 are discussed in Sect. II; column 7 under the head "PROPER MOTION"; column 8 under that of "PRECESSION"; and 10 under that of "SYSTEMATIC CORRECTIONS." Column 9 is the sum of 6, 7, and 8. 11 is explained by the heading.

Column 15 shows the residual of each observation, and 13 and 14 exhibit the computation by which these are derived. This matter has not been treated in detail before, as I deem it rather unimportant for the present purpose. The probable error is not made to depend on the residuals, and they are here recorded merely to give an idea of the interagreement of the observations; they are nowise used in the work. The method is sufficiently explained by the headings; and it is plain that, if carried through as shown, the desired quantities will be obtained, remembering the form of the observation equations (equation (1) of "FORMULÆ FOR ADJUSTMENT," Sect. II).

**Results:** At the end of each table the results are shown. They are as follows: Column 3 contains  $T_0$ ; 5 the total number of observations; 6 the coördinate  $\alpha_0$  or  $\delta_0$  at the time  $T_0$ ; 7 the correction for  $\Delta\mu_0$  to reduce these to 1875; 9 the coördi-

1 B. D. 26°.2324 (2 CHASE).

$\alpha_{1875}$   $12^h$   $12^m$   $22^s.88$   $\mu$ ,  $0^s.000$   
 $\delta_{1875}$   $26^\circ$   $52'$   $58''.1$   $\mu'$ ,  $0''.00$

| No. of Cat.<br>Sec. I. | Authority.                    | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Right Asc.                         | Corr. for<br>Errone's<br>Proper<br>Motion. | Reduction<br>to<br>1875. |
|------------------------|-------------------------------|-----------------|---------------------|-------------------|------------------------------------|--------------------------------------------|--------------------------|
|                        |                               |                 |                     |                   | at Epoch<br>of Cat.                |                                            |                          |
|                        |                               |                 |                     |                   | Declination<br>at Epoch<br>of Cat. |                                            |                          |
|                        |                               | t               | T                   | n                 | h m s                              | s                                          | m s                      |
| 3                      | Lalande 23057                 | 1794.31         | 1800                | 1                 | 12 8 34.89                         | 0.000                                      | +3 48.021                |
| 5                      | Bessel (W <sub>1</sub> .) 229 | 1829.33         | 1825                | 1                 | 9 50.73                            | .000                                       | +2 31.936                |
| 26                     | Paris <sub>3</sub> 15073      | 1874.7          | 1875                | 5                 | 12 22.89                           | .000                                       | —                        |
| 29                     | A. G. C. 6058                 | 1877.2          | 1875                | 6                 | 12 22.88                           | .000                                       | —                        |
| 25                     | Romberg 2710                  | 1880.3          | 1875                | 2                 | 12 22.85                           | .000                                       | —                        |
|                        | <b>Results</b>                | <b>1873.63</b>  | <b>1875</b>         | <b>15</b>         | <b>12 12 22.904</b>                | <b>-0.004</b>                              | —                        |
| 3                      | Lalande 23057                 | 1794.31         | 1800                | 1                 | 26° 77' 55.4"                      | 0.00                                       | -25' 2.72"               |
| 5                      | Bessel (W <sub>1</sub> .) 229 | 1829.33         | 1825                | 1                 | 69 41.5                            | .00                                        | -16 41.64                |
| 26                     | Paris <sub>3</sub> 15073      | 1874.7          | 1875                | 5                 | 52 58.6                            | .00                                        | —                        |
| 29                     | A. G. C. 6058                 | 1877.2          | 1875                | 6                 | 52 58.1                            | .00                                        | —                        |
| 25                     | Romberg 2710                  | 1880.3          | 1875                | 2                 | 52 58.6                            | .00                                        | —                        |
|                        | <b>Results</b>                | <b>1873.63</b>  | <b>1875</b>         | <b>15</b>         | <b>26° 52' 58.12"</b>              | <b>+0.12</b>                               | —                        |

notes for 1875; 10 the probable error at the time  $T_0$ , and 11 that at 1875; 12 the weight of  $\alpha_0$  or  $\delta_0$  at the time  $T_0$ , that is  $[p]$ ; 13 the final proper motion; 14 the probable error of the proper motion; and 15 its weight,  $[CD]$ , at  $T_0$ .

$$J = + 3^s.03565$$

$$I = - 20''.0250$$

$$K = - 0.01215$$

$$M = + 0.0325$$

$$P = + 0.014$$

$$N = + 0.16$$

| Right Ascen.<br>1875.<br><b>a</b> | System-<br>atic Corr. | $\alpha + A.$<br><b>B<sub>a</sub></b> | Weight.    | $\Delta\mu_0(t-T_0).$<br><b>F<sub>a</sub></b>  | Corrected<br>R. A. 1875.<br><b>B<sub>a</sub>' = B<sub>a</sub> + F<sub>a</sub></b> | $\alpha_0 - B_{a'}$<br><b>v<sub>a</sub></b> |
|-----------------------------------|-----------------------|---------------------------------------|------------|------------------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------------|
| Declination<br>1875.<br><b>b</b>  | <b>A</b>              | $\delta + A.$<br><b>B<sub>b</sub></b> | <b>p</b>   | $\Delta\mu_0'(t-T_0).$<br><b>F<sub>b</sub></b> | Corrected<br>Decl. 1875.<br><b>B<sub>b</sub>' = B<sub>b</sub> + F<sub>b</sub></b> | $\delta_0 - B_{b'}$<br><b>v<sub>b</sub></b> |
| h m s                             | s                     | s                                     |            | s                                              | s                                                                                 | s                                           |
| 12 12 22.911                      | +0.254                | 23.165                                | 0.1        | -0.206                                         | 22.959                                                                            | -0.055                                      |
| 12 22.666                         | +0.190                | 22.856                                | 0.1        | -0.115                                         | 22.741                                                                            | +0.163                                      |
| 12 22.890                         | +0.043                | 22.933                                | 2.0        | +0.003                                         | 22.936                                                                            | -0.032                                      |
| 12 22.880                         | .000                  | 22.880                                | 1.0        | +0.009                                         | 22.889                                                                            | +0.015                                      |
| 12 22.850                         | -0.003                | 22.847                                | 1.0        | +0.017                                         | 22.864                                                                            | +0.040                                      |
| h m s                             | s                     | s                                     |            | s                                              | s                                                                                 | s                                           |
| <b>12 12 22.900</b>               | <b>±0.0146</b>        | <b>± 0.0146</b>                       | <b>4.2</b> | <b>-0.0026</b>                                 | <b>± 0.0010</b>                                                                   | <b>885</b>                                  |
| 26 52' 52".68                     | -2.60                 | 50.08                                 | 0.1        | +6.82                                          | 56.90                                                                             | +1.22                                       |
| 52 59.86                          | -3.60                 | 56.26                                 | 0.1        | +3.81                                          | 60.07                                                                             | -1.95                                       |
| 52 58.60                          | -0.22                 | 58.38                                 | 2.0        | -0.09                                          | 58.29                                                                             | -0.17                                       |
| 52 58.10                          | .00                   | 5.0                                   | 1.0        | -0.31                                          | 57.79                                                                             | +0.33                                       |
| 52 58.60                          | +0.01                 | 58.61                                 | 1.0        | -0.57                                          | 58.04                                                                             | +0.08                                       |
| h m s                             | s                     | s                                     |            | s                                              | s                                                                                 | s                                           |
| <b>26 52' 58".24</b>              | <b>±0.195</b>         | <b>± 0.196</b>                        | <b>4.2</b> | <b>+0.086</b>                                  | <b>± 0.0135</b>                                                                   | <b>885</b>                                  |

## 2 B. D. 26°.2326—43 Comæ Berenices (3 CHASE).

$\alpha_{1875}$                        $12^h$              $12^m$              $43^s.81$              $\mu$ ,     $0^s.000$   
 $\delta_{1875}$                        $26^\circ$              $42'$              $10''.5$              $\mu'$ , —  $0''.03$

| No. of Cat.<br>Sec. I. | Authority.                   | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Right Asc.                         |    |        | Corr. for<br>Errone's<br>Proper<br>Motion. | Reduction<br>to<br>1875. |        |
|------------------------|------------------------------|-----------------|---------------------|-------------------|------------------------------------|----|--------|--------------------------------------------|--------------------------|--------|
|                        |                              |                 |                     |                   | at Epoch<br>of Cat.                |    |        |                                            |                          |        |
|                        |                              |                 |                     |                   | Declination<br>at Epoch<br>of Cat. |    |        |                                            |                          |        |
|                        |                              | t               | T                   | n                 | h                                  | m  | s      | s                                          | m                        | s      |
| 4                      | d' Agelet 2893               | 1785.25         | 1800                | 1                 | 12                                 | 8  | 56.2   | 0.000                                      | +3                       | 47.961 |
| 3                      | Lalande 23065                | 1794.31         | 1800                | 1                 |                                    | 8  | 55.83  | .000                                       | +3                       | 47.961 |
| 2                      | Piazzi 39                    | 1805.97         | 1800                | 5                 |                                    | 8  | 55.70  | .000                                       | +3                       | 47.961 |
| 5                      | Bessel (W <sub>1</sub> ) 238 | 1830.32         | 1825                | 2                 | 10                                 | 11 | .79    | .000                                       | +2                       | 31.897 |
| 8                      | Taylor 5644                  | [1835.3]        | 1835                | 3                 | 10                                 | 42 | .60    | .000                                       | +2                       | 1.492  |
| 21                     | Bruxelles 5031               | 1866.66         | 1865                | 3                 | 12                                 | 13 | .38    | .000                                       | +30                      | 355    |
| 33                     | Radcl. An. 632               | 1870.32         | 1870                | 4                 | 12                                 | 28 | .54    | .000                                       | +15                      | 176    |
| 26                     | Paris <sub>3</sub> 15077     | 1872.8          | 1875                | 2                 | 12                                 | 43 | .77    | .000                                       | —                        | —      |
| 29                     | A. G. C. 6061                | 1878.0          | 1875                | 6                 | 12                                 | 43 | .81    | .000                                       | —                        | —      |
| 25                     | Romberg 2711                 | 1879.4          | 1875                | 2                 | 12                                 | 43 | .64    | .000                                       | —                        | —      |
|                        | Results                      | 1863.01         | 1875                | 29                | 12                                 | 12 | 43.790 | —0.059                                     | —                        | —      |
| 4                      | d' Agelet 2893               | 1785.25         | 1800                | 1                 | 26                                 | 67 | 16.3   | —0.44                                      | —25                      | 4.86   |
| 3                      | Lalande 23065                | 1794.31         | 1800                | 1                 |                                    | 67 | 16.2   | —0.17                                      | —25                      | 4.86   |
| 2                      | Piazzi 39                    | 1805.51         | 1800                | 9                 |                                    | 67 | 16.5   | +0.16                                      | —25                      | 4.86   |
| 5                      | Bessel (W <sub>1</sub> ) 238 | 1830.32         | 1825                | 2                 |                                    | 58 | 53.0   | +0.16                                      | —16                      | 43.06  |
| 8                      | Taylor 5644                  | [1834.8]        | 1835                | 4                 |                                    | 55 | 32.80  | .00                                        | —13                      | 22.40  |
| 10                     | Robinson 2639                | 1849.30         | 1840                | 2                 |                                    | 53 | 53.20  | +0.28                                      | —11                      | 42.07  |
| 33                     | Radcl. An. 743               | 1868.24         | 1868                | 1                 |                                    | 44 | 29.91  | +0.01                                      | —2                       | 20.38  |
| 21                     | Bruxelles 5031               | 1868.33         | 1865                | 4                 |                                    | 45 | 30.98  | +0.10                                      | —3                       | 20.55  |
| 33                     | Radcl. An. 632               | 1870.29         | 1870                | 3                 |                                    | 43 | 51.82  | +0.01                                      | —1                       | 40.27  |
| 26                     | Paris <sub>3</sub> 15077     | 1872.8          | 1875                | 2                 |                                    | 42 | 10.9   | —0.07                                      | —                        | —      |
| 29                     | A. G. C. 6061                | 1878.0          | 1875                | 6                 |                                    | 42 | 10.5   | +0.09                                      | —                        | —      |
| 25                     | Romberg 2711                 | 1879.4          | 1875                | 2                 |                                    | 42 | 10.8   | +0.13                                      | —                        | —      |
|                        | Results                      | 1863.17         | 1875                | 37                | 26                                 | 42 | 10.40  | +0.25                                      | —                        | —      |

$$J = + 3^{\circ}.03491$$

$$L = - 20''.0533$$

$$K = - 0.01200$$

$$M = + 0.0332$$

$$P = + 0.013$$

$$N = + 0.16$$

| Right Ascen.<br>1875.<br>$\alpha$ | System-<br>atic Corr. | $a + A.$<br>$B_a$           | Weight.          | $\Delta\mu_0(t-T_0).$<br>$F_a$       | Corrected<br>R. A. 1875.<br>$B_a' = B_a + F_a$                | $a_0 - B_a'$<br>$v_a$                |
|-----------------------------------|-----------------------|-----------------------------|------------------|--------------------------------------|---------------------------------------------------------------|--------------------------------------|
| Declination<br>1875.<br>$\delta$  | $A$                   | $\delta + A.$<br>$B_\delta$ | $p$              | $\Delta\mu_0'(t-T_0).$<br>$F_\delta$ | Corrected<br>Decl. 1875.<br>$B_\delta' = B_\delta + F_\delta$ | $\delta_0 - B_\delta'$<br>$v_\delta$ |
| h m s                             | s                     | s                           |                  | s                                    | s                                                             | s                                    |
| 12 12 44.161                      | +0.332                | 44.493                      | 0.1              | -0.381                               | 44.112                                                        | -0.322                               |
| 12 43.791                         | +0.253                | 44.044                      | 0.1 <sub>2</sub> | -0.337                               | 43.707                                                        | +0.083                               |
| 12 43.661                         | +0.253                | 43.914                      | 0.3              | -0.279                               | 43.635                                                        | +0.155                               |
| 12 43.687                         | +0.156                | 43.843                      | 0.2              | -0.160                               | 43.683                                                        | +0.107                               |
| 12 44.092                         | -0.059                | 44.033                      | 0.5              | -0.136                               | 43.897                                                        | -0.107                               |
| 12 43.735                         | +0.043                | 43.778                      | 1.0              | +0.018                               | 43.796                                                        | -0.006                               |
| 12 43.716                         | -0.071                | 43.645                      | 1.0              | +0.036                               | 43.681                                                        | +0.109                               |
| 12 43.770                         | +0.043                | 43.813                      | 1.0              | +0.048                               | 43.861                                                        | -0.071                               |
| 12 43.810                         | .000                  | 43.810                      | 1.0              | +0.073                               | 43.883                                                        | -0.093                               |
| 12 43.640                         | -0.003                | 43.637                      | 1.0              | +0.080                               | 43.717                                                        | +0.073                               |
| h m s                             | s                     | s                           |                  | s                                    | s                                                             | s                                    |
| <b>12 12 43.731</b>               | $\pm 0.0120$          | $\pm 0.0136$                | <b>6.2</b>       | <b>-0.0049</b>                       | $\pm 0.0005$                                                  | <b>3306</b>                          |
| 26 42 11.00                       | -1.41                 | 9.59                        | 0.1              | +1.64                                | 11.23                                                         | -0.83                                |
| 42 11.17                          | -2.63                 | 8.54                        | 0.1              | +1.45                                | 9.99                                                          | +0.41                                |
| 42 11.80                          | -2.63                 | 9.17                        | 0.3              | +1.21                                | 10.38                                                         | +0.02                                |
| 42 10.10                          | -0.22                 | 9.88                        | 0.2              | +0.69                                | 10.57                                                         | -0.17                                |
| 42 10.40                          | -0.82                 | 9.58                        | 0.5              | +0.60                                | 10.18                                                         | +0.22                                |
| 42 11.41                          | -0.84                 | 10.57                       | 0.2              | +0.29                                | 10.86                                                         | -0.46                                |
| 42 9.54                           | +0.03                 | 9.57                        | 0.5              | -0.11                                | 9.46                                                          | +0.94                                |
| 42 10.53                          | -0.01                 | 10.52                       | 1.0              | -0.11                                | 10.41                                                         | -0.01                                |
| 42 11.56                          | -0.68                 | 10.88                       | 1.0              | -0.15                                | 10.73                                                         | -0.33                                |
| 42 10.83                          | -0.22                 | 10.61                       | 1.0              | -0.20                                | 10.41                                                         | -0.01                                |
| 42 10.59                          | .00                   | 10.59                       | 1.0              | -0.31                                | 10.28                                                         | +0.12                                |
| 42 10.93                          | .00                   | 10.93                       | 1.0              | -0.34                                | 10.59                                                         | -0.19                                |
| <b>26 42 10.65</b>                | $\pm 0.152$           | $\pm 0.173$                 | <b>6.9</b>       | <b>-0.009</b>                        | $\pm 0.0069$                                                  | <b>3402</b>                          |



## 3 B. D. 26°.2329—51 Comæ Berenices (5 CHASE).

$$\begin{array}{cccccc} \alpha_{1875} & 12^h & 14^m & 1^s.05 & \mu, & 0^s.000 \\ \delta_{1875} & 26^\circ & 41' & 42''.6 & \mu', & +0''.03 \end{array}$$

| No. of Cat.<br>Sec. I. | Authority.                   | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Right Asc.                         | Corr. for<br>Errone's<br>Proper<br>Motion. | Reduction<br>to<br>1875. |
|------------------------|------------------------------|-----------------|---------------------|-------------------|------------------------------------|--------------------------------------------|--------------------------|
|                        |                              |                 |                     |                   | at Epoch<br>of Cat.                |                                            |                          |
|                        |                              |                 |                     |                   | Declination<br>at Epoch<br>of Cat. |                                            |                          |
|                        |                              | t               | T                   | n                 | h m s                              | s                                          | m s                      |
| 4                      | d'Agelet 2909                | 1785.25         | 1800                | 1                 | 12 10 14.1                         | 0.000                                      | +3 47.677                |
| 3                      | Lalande 23118                | 1794.31         | 1800                | 1                 | 10 14.30                           | .000                                       | +3 47.677                |
| 2                      | Piazzi 52                    | 1802.99         | 1800                | 16                | 10 14.24                           | .000                                       | +3 47.677                |
| 5                      | Bessel (W <sub>1</sub> ) 270 | 1831.31         | 1825                | 1                 | 11 29.76                           | .000                                       | +2 31.708                |
| 8                      | Taylor 5659                  | [1835.3]        | 1835                | 2                 | 12 0.53                            | .000                                       | +2 1.341                 |
| 21                     | Bruxelles 5045               | 1866.66         | 1865                | 3                 | 13 30.84                           | .000                                       | +30.318                  |
| 33                     | Radcl. An. 636               | 1870.35         | 1870                | 2                 | 13 46.25                           | .000                                       | 15.157                   |
| 33                     | Radcl. An. 624               | 1873.24         | 1873                | 1                 | 13 55.03                           | .000                                       | 6.063                    |
| 26                     | Paris <sub>3</sub> 15100     | 1875.6          | 1875                | 3                 | 14 1.09                            | .000                                       | —                        |
| 29                     | A. G. C. 6070                | 1876.3          | 1875                | 6                 | 14 1.05                            | .000                                       | —                        |
| 25                     | Romberg 2725                 | 1879.9          | 1875                | 2                 | 14 1.02                            | .000                                       | —                        |
|                        | Results                      | 1864.89         | 1875                | 38                | 12 14 1.255                        | -0.142                                     | —                        |
|                        |                              |                 |                     |                   | h m s                              | s                                          | m s                      |
| 4                      | d'Agelet 2909                | 1785.25         | 1800                | 1                 | 26 66' 44.2                        | +0.44                                      | -24' 59.94               |
| 3                      | Lalande 23118                | 1794.31         | 1800                | 1                 | 66 47.2                            | +0.17                                      | -24 59.94                |
| 2                      | Piazzi 52                    | 1804.05         | 1800                | 10                | 66 44.6                            | -0.12                                      | -24 59.94                |
| 5                      | Bessel (W <sub>1</sub> ) 270 | 1831.31         | 1825                | 1                 | 58 18.9                            | -0.19                                      | -16 39.76                |
| 8                      | Taylor 5659                  | [1834.8]        | 1835                | 4                 | 55 3.11                            | .00                                        | -13 19.74                |
| 10                     | Robinson 2649                | 1849.30         | 1840                | 2                 | 53 26.22                           | -0.28                                      | -11 39.75                |
| 33                     | Radcl. An. 747               | 1868.24         | 1868                | 1                 | 44 2.01                            | -0.01                                      | -2 19.92                 |
| 21                     | Bruxelles 5045               | 1868.33         | 1865                | 4                 | 45 3.01                            | -0.10                                      | -3 19.88                 |
| 33                     | Radcl. An. 636               | 1870.37         | 1870                | 1                 | 43 25.55                           | -0.01                                      | -1 39.94                 |
| 33                     | Radcl. An. 624               | 1873.24         | 1873                | 1                 | 42 22.72                           | -0.01                                      | -39.97                   |
| 26                     | Paris <sub>3</sub> 15100     | 1875.6          | 1875                | 3                 | 41 42.5                            | -0.02                                      | —                        |
| 29                     | A. G. C. 6070                | 1876.3          | 1875                | 6                 | 41 42.6                            | -0.04                                      | —                        |
| 25                     | Romberg 2725                 | 1879.9          | 1875                | 2                 | 41 43.5                            | -0.15                                      | —                        |
|                        | Results                      | 1864.06         | 1875                | 37                | 26 41' 42.94                       | 0.00                                       | —                        |

$$J = + 3^{\circ}.03116$$

$$L = - 19''.9867$$

$$K = - 0.01188$$

$$M = + 0.0356$$

$$P = + 0.013$$

$$N = + 0.16$$

| Right Ascen.<br>1875.<br>$\alpha$ | System-<br>atic Corr. | $\alpha + A$ .<br>$B_{\alpha}$ | Weight. | $\Delta\mu_0(t-T_0)$<br>$F_{\alpha}$  | Corrected<br>R. A. 1875.<br>$B_{\alpha}' = B_{\alpha} + F_{\alpha}$ | $\alpha_0 - B_{\alpha}'$<br>$v_{\alpha}$ |
|-----------------------------------|-----------------------|--------------------------------|---------|---------------------------------------|---------------------------------------------------------------------|------------------------------------------|
| Declination<br>1875.<br>$\delta$  | $\Lambda$             | $\delta + A$ .<br>$B_{\delta}$ | $p$     | $\Delta\mu_0'(t-T_0)$<br>$F_{\delta}$ | Corrected<br>Decl. 1875.<br>$B_{\delta}' = B_{\delta} + F_{\delta}$ | $\delta_0 - B_{\delta}'$<br>$v_{\delta}$ |
| h m s                             | s                     | s                              |         | s                                     | s                                                                   | s                                        |
| 12 14 1.777                       | +0.332                | 2.109                          | 0.1     | -1.115                                | 0.994                                                               | +0.261                                   |
| 14 1.977                          | +0.253                | 2.230                          | 0.1     | -0.988                                | 1.242                                                               | +0.013                                   |
| 14 1.917                          | +0.253                | 2.170                          | 0.3     | -0.867                                | 1.303                                                               | -0.048                                   |
| 14 1.468                          | +0.122                | 1.590                          | 0.1     | -0.470                                | 1.120                                                               | +0.135                                   |
| 14 1.871                          | -0.059                | 1.812                          | 0.3     | -0.414                                | 1.398                                                               | -0.143                                   |
| 14 1.158                          | +0.043                | 1.201                          | 1.0     | +0.025                                | 1.226                                                               | +0.029                                   |
| 14 1.407                          | -0.071                | 1.336                          | 0.5     | +0.076                                | 1.412                                                               | -0.157                                   |
| 14 1.093                          | .000 <sup>1</sup>     | 1.093                          | 0.5     | +0.117                                | 1.210                                                               | +0.045                                   |
| 14 1.090                          | +0.043                | 1.133                          | 1.0     | +0.150                                | 1.283                                                               | -0.028                                   |
| 14 1.050                          | .000                  | 1.050                          | 1.0     | +0.160                                | 1.210                                                               | +0.045                                   |
| 14 1.020                          | - .003                | 1.017                          | 1.0     | +0.210                                | 1.227                                                               | +0.028                                   |
| 12 14 1.113                       | +0.0123               | +0.0134                        | 5.9     | -0.0140                               | $\pm 0.0005$                                                        | 3180                                     |
| 26 41 44.70                       | -1.41                 | 43.29                          | 0.1     | .00                                   | 43.29                                                               | -0.35                                    |
| 41 47.43                          | -2.63                 | 44.80                          | 0.1     | .00                                   | 44.80                                                               | -1.86                                    |
| 41 44.54                          | -2.63                 | 41.91                          | 0.3     | .00                                   | 41.91                                                               | +1.03                                    |
| 41 38.95                          | +3.15                 | 42.10                          | 0.1     | .00                                   | 42.10                                                               | +0.84                                    |
| 41 43.37                          | -0.81                 | 42.56                          | 0.5     | .00                                   | 42.56                                                               | +0.38                                    |
| 41 46.19                          | -0.82                 | 45.37                          | 0.2     | .00                                   | 45.37                                                               | -2.43                                    |
| 41 42.08                          | +0.03                 | 42.11                          | 0.5     | .00                                   | 42.11                                                               | +0.83                                    |
| 41 43.03                          | -0.01                 | 43.02                          | 1.0     | .00                                   | 43.02                                                               | -0.08                                    |
| 41 45.60                          | -0.68                 | 44.92                          | 0.5     | .00                                   | 44.92                                                               | -1.98                                    |
| 41 42.74                          | -0.11                 | 42.63                          | 0.5     | .00                                   | 42.63                                                               | +0.31                                    |
| 41 42.48                          | -0.22                 | 42.26                          | 1.0     | .00                                   | 42.26                                                               | +0.68                                    |
| 41 42.56                          | .00                   | 42.56                          | 1.0     | .00                                   | 42.56                                                               | +0.38                                    |
| 41 43.35                          | .00                   | 43.35                          | 1.0     | .00                                   | 43.35                                                               | -0.41                                    |
| 26 41 42.94                       | $\pm 0.153$           | $\pm 0.171$                    | 6.8     | +0.030                                | $\pm 0.0069$                                                        | 3390                                     |

<sup>1</sup> NOTE: See Sect. II, Systematic Corrections to Radcliffe Annuals.

## 4 B. D. 27°.2114 (6 CHASE).

$\alpha_{1875}$                        $12^h$                        $14^m$                        $2^s.52$                        $\mu$ ,                       $0^s.000$   
 $\delta_{1875}$                        $27^\circ$                        $19'$                        $1''.5$                        $\mu'$ , —  $0''.13$

| No. of Cat.<br>Sec. I. | Authority.     | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Right Asc.          |           | Corr. for<br>Errone's<br>Proper<br>Motion. | Reduction<br>to<br>1875. |
|------------------------|----------------|-----------------|---------------------|-------------------|---------------------|-----------|--------------------------------------------|--------------------------|
|                        |                |                 |                     |                   | at Epoch<br>of Cat. |           |                                            |                          |
|                        |                |                 |                     |                   | h                   | m s       |                                            |                          |
| 3                      | Lalande 23120  | 1794.31         | 1800                | 1                 | 12                  | 10 15.05  | 0.000                                      | + 3 47.598               |
| 12                     | Paris, 15101   | 1841.2          | 1845                | 2                 | 12                  | 31.76     | .000                                       | + 1 30.954               |
| 9                      | Rümker 3916    | [1841.3]        | 1836                | 1                 | 12                  | 4.481     | .000                                       | + 1 58.262               |
| 16                     | Poulkova 1852  | 1841.32         | 1855                | 4                 | 13                  | 2.08      | .000                                       | + 1 0.624                |
| 31                     | Camb. An.      | 1847.31         | 1847                | 1                 | 12                  | 37.82     | .000                                       | + 1 24.887               |
| 13                     | Jacob [4153]   | 1850.27         | 1850                | 4                 | 12                  | 46.66     | .000                                       | + 1 15.788               |
| 14                     | Wrottesley 447 | 1851.1          | 1850                | 5                 | 12                  | 46.86     | .000                                       | + 1 15.788               |
| 32                     | Edinb. An.     | 1856.22         | 1856                | 2                 | 13                  | 5.12      | .000                                       | + 57.592                 |
| 32                     | " "            | 1858.21         | 1858                | 5                 | 13                  | 11.16     | .000                                       | + 51.527                 |
| 32                     | " "            | 1864.26         | 1864                | 2                 | 13                  | 29.42     | .000                                       | + 33.337                 |
| 32                     | " "            | 1865.16         | 1865                | 1                 | 13                  | 32.36     | .000                                       | + 30.306                 |
| 20                     | Yarnall 5240   | 1866.0          | 1860                | 3                 | 13                  | 17.06     | .000                                       | + 45.463                 |
| 32                     | Edinb. An.     | 1868.26         | 1868                | 3                 | 13                  | 41.37     | .000                                       | + 21.213                 |
| 33                     | Radcl. An. 637 | 1870.24         | 1870                | 1                 | 13                  | 47.34     | .000                                       | + 15.151                 |
| 26                     | Paris, 15101   | 1875.3          | 1875                | 1                 | 14                  | 2.49      | .000                                       | —                        |
| 29                     | A. G. C. 6071  | 1877.3          | 1875                | 7                 | 14                  | 2.52      | .000                                       | —                        |
| 25                     | Romberg 2726   | 1879.4          | 1875                | 2                 | 14                  | 2.45      | .000                                       | —                        |
| 30                     | Ten-Year 1927  | 1880.02         | 1880                | 3                 | 14                  | 17.660    | .000                                       | — 15.148                 |
| Results                |                |                 |                     |                   | h m s               | s         |                                            |                          |
|                        |                |                 |                     |                   | 12 14               | 2.624     | —0.104                                     | —                        |
| 3                      | Lalande 23120  | 1794.31         | 1800                | 1                 | 27                  | 44' 16.8" | —0.74                                      | —25' 11" 93              |
| 9                      | Rümker 3916    | [1841.3]        | 1836                | 1                 | 32                  | 10.01     | +0.69                                      | —13 5.98                 |
| 16                     | Poulkova 1852  | 1841.32         | 1855                | 4                 | 25                  | 46.2      | —1.78                                      | — 6 43.00                |
| 12                     | Paris, 15101   | 1845.3          | 1845                | 1                 | 29                  | 7.5       | +0.04                                      | —10 4.56                 |
| 31                     | Camb. An.      | 1847.35         | 1847                | 1                 | 28                  | 27.98     | +0.05                                      | — 9 24.24                |
| 13                     | Jacob [4153]   | 1850.27         | 1850                | 4                 | 27                  | 26.19     | +0.04                                      | — 8 23.78                |
| 20                     | Yarnall 5240   | 1854.4          | 1860                | 3                 | 24                  | 3.7       | —0.73                                      | — 5 2.24                 |
| 32                     | Edinb. An.     | 1855.31         | 1855                | 1                 | 25                  | 45.5      | +0.04                                      | — 6 43.00                |
| 32                     | " "            | 1858.21         | 1858                | 7                 | 24                  | 44.3      | +0.03                                      | — 5 42.54                |
| 32                     | " "            | 1859.25         | 1859                | 2                 | 24                  | 23.8      | +0.03                                      | — 5 22.39                |
| 32                     | " "            | 1860.23         | 1860                | 6                 | 24                  | 4.7       | +0.03                                      | — 5 2.24                 |
| 32                     | " "            | 1863.19         | 1863                | 3                 | 23                  | 2.6       | +0.02                                      | — 4 1.78                 |
| 32                     | " "            | 1864.26         | 1864                | 7                 | 22                  | 43.8      | +0.03                                      | — 3 41.64                |
| 32                     | " "            | 1865.26         | 1865                | 3                 | 22                  | 22.9      | +0.03                                      | — 3 21.48                |
| 33                     | Radcl. An. 413 | 1865.27         | 1865                | 2                 | 22                  | 23.63     | +0.04                                      | — 3 21.48                |
| 32                     | Edinb. An.     | 1866.27         | 1866                | 3                 | 22                  | 4.0       | +0.04                                      | — 3 1.33                 |
| 32                     | " "            | 1867.23         | 1867                | 2                 | 21                  | 44.7      | +0.03                                      | — 2 41.18                |
| 32                     | " "            | 1868.27         | 1868                | 5                 | 21                  | 24.0      | +0.04                                      | — 2 21.04                |
| 33                     | Radcl. An. 748 | 1868.27         | 1868                | 3                 | 21                  | 21.96     | +0.04                                      | — 2 21.04                |
| 32                     | Edinb. An.     | 1869.31         | 1869                | 4                 | 21                  | 5.4       | +0.04                                      | — 2 0.89                 |
| 33                     | Radcl. An. 637 | 1870.24         | 1870                | 1                 | 20                  | 42.88     | +0.03                                      | — 1 40.74                |
| 33                     | " " 594        | 1871.28         | 1871                | 4                 | 20                  | 22.74     | +0.04                                      | — 1 20.59                |
| 33                     | " " 625        | 1873.36         | 1873                | 2                 | 19                  | 40.56     | +0.05                                      | — 40.29                  |
| 26                     | Paris, 15101   | 1875.3          | 1875                | 1                 | 19                  | 2.1       | +0.04                                      | —                        |
| 29                     | A. G. C. 6071  | 1877.3          | 1875                | 7                 | 19                  | 1.5       | +0.30                                      | —                        |
| 25                     | Romberg 2726   | 1879.4          | 1875                | 2                 | 19                  | 2.7       | +0.57                                      | —                        |
| 30                     | Ten-Year 1927  | 1880.02         | 1880                | 3                 | 17                  | 22.98     | .00                                        | + 1 40.73                |
| Results                |                |                 |                     |                   | 27 19               | 1.98      | +0.28                                      | —                        |

$$J = +3^{\circ}.02997$$

$$K = -0.01225$$

$$P = +0.014$$

$$L = -20''.1466$$

$$M = +0.0357$$

$$N = +0.16$$

| Right Ascen.<br>1875.<br>$\alpha$ | System-<br>atic Corr. | $a + A.$<br>$B_a$           | Weight. | $\Delta\mu_0(t-T_0).$<br>$F_a$       | Corrected<br>R. A. 1875.<br>$B_a' = B_a + F_a$                | $a_0 - B_a'$<br>$v_a$                |
|-----------------------------------|-----------------------|-----------------------------|---------|--------------------------------------|---------------------------------------------------------------|--------------------------------------|
| Declination<br>1875.<br>$\delta$  | $\Lambda$             | $\delta + A.$<br>$B_\delta$ | $p$     | $\Delta\mu_0'(t-T_0).$<br>$F_\delta$ | Corrected<br>Decl. 1875.<br>$B_\delta' = B_\delta + F_\delta$ | $\delta_0 - B_\delta'$<br>$v_\delta$ |
| h m s                             | s                     | s                           |         | s                                    | s                                                             | s                                    |
| 12 14 2.648                       | +0.255                | 2.903                       | 0.1     | -0.469                               | 2.434                                                         | +0.190                               |
| 14 2.714                          | +0.047                | 2.761                       | 0.7     | -0.136                               | 2.625                                                         | -0.001                               |
| 14 2.743                          | +0.039                | 2.782                       | 0.1     | -0.135                               | 2.647                                                         | -0.023                               |
| 14 2.704                          | +0.058                | 2.762                       | 2.0     | -0.135                               | 2.627                                                         | -0.003                               |
| 14 2.707                          | .000 <sup>1</sup>     | 2.707                       | 0.3     | -0.092                               | 2.615                                                         | +0.009                               |
| 14 2.448                          | +0.310                | 2.758                       | 0.5     | -0.071                               | 2.687                                                         | -0.063                               |
| 14 2.648                          | +0.163                | 2.811                       | 0.5     | -0.065                               | 2.746                                                         | -0.122                               |
| 14 2.712                          | -0.087                | 2.625                       | 0.1     | -0.029                               | 2.596                                                         | +0.028                               |
| 14 2.687                          | -0.087                | 2.600                       | 0.6     | -0.015                               | 2.585                                                         | +0.039                               |
| 14 2.757                          | -0.070                | 2.687                       | 0.1     | +0.028                               | 2.715                                                         | -0.091                               |
| 14 2.666                          | -0.042                | 2.624                       | 0.1     | +0.035                               | 2.659                                                         | -0.035                               |
| 14 2.523                          | +0.033                | 2.556                       | 0.6     | +0.040                               | 2.596                                                         | +0.028                               |
| 14 2.583                          | -0.042                | 2.541                       | 0.3     | +0.057                               | 2.598                                                         | +0.026                               |
| 14 2.491                          | -0.071                | 2.420                       | 0.5     | +0.071                               | 2.491                                                         | +0.133                               |
| 14 2.490                          | +0.043                | 2.533                       | 0.5     | +0.106                               | 2.639                                                         | -0.015                               |
| 14 2.520                          | .000                  | 2.520                       | 1.0     | +0.121                               | 2.641                                                         | -0.017                               |
| 14 2.450                          | -0.003                | 2.447                       | 1.0     | +0.136                               | 2.583                                                         | +0.041                               |
| 14 2.512                          | +0.010                | 2.522                       | 1.0     | +0.140                               | 2.662                                                         | -0.038                               |
| h m s                             | s                     | s                           |         | s                                    | s                                                             |                                      |
| 12 14 2.520                       | $\pm 0.0094$          | $\pm 0.0125$                | 10.0    | -0.0071                              | $\pm 0.0006$                                                  | 2842                                 |
| 27 19 4.13                        | -2.58                 | 1.55                        | 0.1     | +1.66                                | 3.21                                                          | -1.23                                |
| 19 4.72                           | -0.32                 | 4.40                        | 0.1     | +0.53                                | 4.93                                                          | -2.95                                |
| 19 1.42                           | -0.02                 | 1.40                        | 2.0     | +0.53                                | 1.93                                                          | +0.05                                |
| 19 2.98                           | -0.45                 | 2.53                        | 0.3     | +0.43                                | 2.96                                                          | -0.98                                |
| 19 3.79                           | -1.62                 | 2.17                        | 0.3     | +0.38                                | 2.55                                                          | -0.57                                |
| 19 2.45                           | -0.13                 | 2.32                        | 0.5     | +0.31                                | 2.63                                                          | -0.65                                |
| 19 0.73                           | -0.10                 | 0.63                        | 0.6     | +0.22                                | 0.85                                                          | +1.13                                |
| 19 2.54                           | -0.70                 | 1.84                        | 0.1     | +0.19                                | 2.03                                                          | -0.05                                |
| 19 1.79                           | -0.66                 | 1.13                        | 0.6     | +0.12                                | 1.75                                                          | +0.73                                |
| 19 1.44                           | -0.64                 | 0.80                        | 0.1     | +0.10                                | 0.90                                                          | +1.08                                |
| 19 2.49                           | -0.62                 | 1.87                        | 0.6     | +0.08                                | 1.95                                                          | +0.03                                |
| 19 0.84                           | +0.26                 | 1.10                        | 0.3     | .00                                  | 1.10                                                          | +0.88                                |
| 19 2.19                           | +0.28                 | 2.47                        | 0.6     | -0.02                                | 2.45                                                          | -0.47                                |
| 19 1.45                           | -0.22                 | 1.23                        | 0.3     | -0.05                                | 1.18                                                          | +0.80                                |
| 19 2.18                           | -0.40                 | 1.78                        | 0.5     | -0.05                                | 1.73                                                          | +0.25                                |
| 19 2.71                           | -0.07                 | 2.64                        | 0.3     | -0.07                                | 2.57                                                          | -0.59                                |
| 19 3.55                           | -0.07                 | 3.48                        | 0.1     | -0.09                                | 3.39                                                          | -1.41                                |
| 19 3.00                           | -0.06                 | 2.94                        | 0.6     | -0.12                                | 2.82                                                          | -0.84                                |
| 19 0.96                           | +0.02                 | 0.98                        | 1.0     | -0.12                                | 0.86                                                          | +1.12                                |
| 19 4.55                           | -0.05                 | 4.50                        | 0.3     | -0.14                                | 4.36                                                          | -2.38                                |
| 19 2.17                           | -0.68                 | 1.49                        | 0.5     | -0.16                                | 1.33                                                          | +0.65                                |
| 19 2.19                           | -0.30                 | 1.89                        | 1.0     | -0.19                                | 1.70                                                          | +0.28                                |
| 19 0.32                           | -0.11                 | 0.21                        | 0.5     | -0.24                                | .03                                                           | +2.01                                |
| 19 2.14                           | -0.22                 | 1.92                        | 0.5     | -0.29                                | 1.63                                                          | +0.35                                |
| 19 1.80                           | .00                   | 1.80                        | 1.0     | -0.33                                | 1.47                                                          | +0.51                                |
| 19 3.27                           | +0.03                 | 3.30                        | 1.0     | -0.38                                | 2.92                                                          | -0.94                                |
| 19 3.71                           | +0.08                 | 3.79                        | 1.0     | -0.40                                | 3.39                                                          | -1.41                                |
| 27 19 2.26                        | $\pm 0''.104$         | $\pm 0''.136$               | 14.8    | -0.106                               | $\pm 0.0075$                                                  | 2829                                 |

<sup>1</sup> Note: See Sect. II, Systematic Corrections to Cambridge Annuals.

## 5 B. D. 26°.2332 (9 CHASE).

$$\begin{array}{rclcl} \alpha_{1875} & 12^h & 14^m & 47^s.43 & \mu, \quad 0^s.000 \\ \delta_{1875} & 26^0 & 24' & 53''.1 & \mu', \quad 0''.00 \end{array}$$

| No. of Cat.<br>Sec. I. | Authority.                   | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Right Asc.<br>at Epoch<br>of Cat.          | Corr. for<br>Errone's<br>Proper<br>Motion. | Reduction<br>to<br>1875. |
|------------------------|------------------------------|-----------------|---------------------|-------------------|--------------------------------------------|--------------------------------------------|--------------------------|
|                        |                              |                 |                     |                   | Declination<br>at Epoch<br>of Cat.         |                                            |                          |
|                        |                              |                 |                     |                   | $h \quad m \quad s$                        |                                            |                          |
| 3                      | Lalande 23134                | 1794.32         | 1800                | 1                 | 12 10 59.80                                | 0.000                                      | +3 47.539                |
| 5                      | Bessel (W <sub>1</sub> ) 289 | 1831.31         | 1825                | 1                 | 12 15.91                                   | .000                                       | +2 31.618                |
| 12                     | Paris <sub>1</sub> 15113     | 1848.0          | 1845                | 1                 | 13 16.36                                   | .000                                       | +1 30.935                |
| 17                     | Argelander 2332              | 1858.29         | 1855                | 1                 | 13 46.54                                   | .000                                       | +1 0.612                 |
| 29                     | A. G. C. 6078                | 1875.1          | 1875                | 5                 | 14 47.43                                   | .000                                       | —                        |
|                        | <b>Results</b>               | <b>1861.01</b>  | <b>1875</b>         | <b>9</b>          | $h \quad m \quad s$<br><b>12 14 47.409</b> | $s$<br><b>—0.022</b>                       | $m \quad s$<br><b>—</b>  |
| 3                      | Lalande 23134                | 1794.32         | 1800                | 1                 | 26 50' 4.9 <sup>1</sup>                    | 0.00                                       | —25' 1.91                |
| 5                      | Bessel (W <sub>1</sub> ) 289 | 1831.31         | 1825                | 1                 | 41 33.1                                    | .00                                        | —16 41.07                |
| 17                     | Argelander 2332              | 1858.29         | 1855                | 1                 | 31 35.1                                    | .00                                        | — 6 40.32                |
| 26                     | Paris <sub>3</sub> 15113     | 1873.3          | 1875                | 1                 | 24 53.9                                    | .00                                        | —                        |
| 29                     | A. G. C. 6078                | 1875.1          | 1875                | 5                 | 24 53.1                                    | .00                                        | —                        |
|                        | <b>Results</b>               | <b>1866.30</b>  | <b>1875</b>         | <b>9</b>          | <b>26 21' 53.82</b>                        | <b>—0.68</b>                               | <b>—</b>                 |

<sup>1</sup> NOTE: According to Paris<sub>3</sub>, p. [99] this should be corrected — 10''; I have not



$$J = + 3^{\text{h}}.02942$$

$$L = -20''.0125$$

$$K = -0.01164$$

$$M = +0.0371$$

$$P = +0.013$$

$$N = +0.16$$

| Right Ascen.<br>1875.<br>$\alpha$ | System-<br>atic Corr. | $\alpha + A$ ,<br>$B_{\alpha}$ | Weight.    | $\Delta\mu_0(t-T_0)$<br>$F_{\alpha}$  | Corrected<br>R. A. 1875.<br>$B_{\alpha}' = B_{\alpha} + F_{\alpha}$ | $\alpha_0 - B_{\alpha}'$<br>$V_{\alpha}$ |
|-----------------------------------|-----------------------|--------------------------------|------------|---------------------------------------|---------------------------------------------------------------------|------------------------------------------|
| Declination<br>1875.<br>$\delta$  | $A$                   | $\delta + A$ ,<br>$B_{\delta}$ | $p$        | $\Delta\mu_0'(t-T_0)$<br>$F_{\delta}$ | Corrected<br>Decl. 1875.<br>$B_{\delta}' = B_{\delta} + F_{\delta}$ | $\delta_0 - B_{\delta}'$<br>$V_{\delta}$ |
| h m s                             | s                     | s                              |            | s                                     | s                                                                   | s                                        |
| 12 14 47.339                      | +0.253                | 47.592                         | 0.1        | -0.107                                | 47.485                                                              | -0.076                                   |
| 14 47.528                         | +0.122                | 47.650                         | 0.1        | -0.048                                | 47.602                                                              | -0.193                                   |
| 14 47.295                         | +0.047                | 47.342                         | 0.3        | -0.021                                | 41.321                                                              | +0.088                                   |
| 14 47.152                         | +0.037                | 47.189                         | 0.2        | -0.004                                | 47.185                                                              | +0.224                                   |
| 14 47.430                         | .000                  | 47.430                         | 1.0        | +0.023                                | 47.453                                                              | -0.044                                   |
| h m s                             | s                     | s                              |            | s                                     | s                                                                   | s                                        |
| <b>12 14 47.387</b>               | $\pm 0.0229$          | $\pm 0.0273$                   | <b>1.7</b> | <b>-0.0016</b>                        | $\pm 0.0011$                                                        | <b>784</b>                               |
| ° ' "                             | "                     | "                              |            | "                                     | "                                                                   | "                                        |
| 26 24 62 99                       | -2.63                 | 60.36                          | 0.1        | -5.61                                 | 54.75                                                               | -0.93                                    |
| 24 52.03                          | +3.15                 | 55.18                          | 0.1        | -2.73                                 | 52.45                                                               | +1.37                                    |
| 24 54.78                          | -0.94                 | 53.84                          | 0.2        | -0.62                                 | 53.22                                                               | +0.60                                    |
| 24 53.90                          | -0.22                 | 53.68                          | 0.5        | +0.55                                 | 54.23                                                               | -0.41                                    |
| 24 53.10                          | .00                   | 53.10                          | 1.0        | +0.69                                 | 53.79                                                               | +0.03                                    |
| <b>26 24 53.14</b>                | $\pm 0.290$           | $\pm 0.317$                    | <b>1.9</b> | <b>-0.078</b>                         | $\pm 0.0146$                                                        | <b>755</b>                               |

done so, however, for obvious reasons.

\*

## 6 B. D. 25°.2493 (10 CHASE).

$\alpha_{1875}$                        $12^h$      $14^m$      $47^s.52$                        $\mu, 0^s.000$   
 $\delta_{1875}$                        $25^\circ$      $43'$      $14''.9$                        $\mu', 0''.00$

| No. of Cat.<br>Sec. I. | Authority.               | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Right Asc.<br>at Epoch<br>of Cat.  | Corr. for<br>Errone's<br>Proper<br>Motion. | Reduction<br>to<br>1875. |
|------------------------|--------------------------|-----------------|---------------------|-------------------|------------------------------------|--------------------------------------------|--------------------------|
|                        |                          |                 |                     |                   | Declination<br>at Epoch<br>of Cat. |                                            |                          |
|                        |                          | t               | T                   | n                 | h m s                              | s                                          | m s                      |
| 3                      | Lalande 23136            | 1794.32         | 1800                | 1                 | 12 11 1.00                         | 0.000                                      | +3 47.624                |
| 31                     | Cambr. An.               | 1845.24         | 1845                | 3                 | 13 16.98                           | .000                                       | +1 30.972                |
| 24                     | Dreyer 1417              | 1872.65         | 1875                | 3                 | 14 47.45                           | .000                                       | —                        |
| 26                     | Paris <sub>3</sub> 15114 | 1873.1          | 1875                | 4                 | 14 47.61                           | .000                                       | —                        |
| 29                     | A. G. C. 6079            | 1880.4          | 1875                | 5                 | 14 47.52                           | .000                                       | —                        |
|                        | <b>Results</b>           | <b>1865.34</b>  | <b>1875</b>         | <b>16</b>         | <b>12 14 47.744</b>                | <b>-0.160</b>                              | —                        |
| 3                      | Lalande 23136            | 1794.32         | 1800                | 1                 | 25 68' 8.0                         | 0.00                                       | -25' 1.91                |
| 31                     | Cambr. An.               | 1843.36         | 1843                | 1                 | 53 52.29                           | .00                                        | -10 40.59                |
| 31                     | " "                      | 1845.34         | 1845                | 1                 | 53 10.91                           | .00                                        | -10 0.54                 |
| 26                     | Paris <sub>3</sub> 15114 | 1873.1          | 1875                | 5                 | 43 14.9                            | .00                                        | —                        |
| 24                     | Dreyer 1417              | 1875.82         | 1875                | 2                 | 43 13.7                            | .00                                        | —                        |
| 29                     | A. G. C. 6079            | 1880.4          | 1875                | 5                 | 43 14.9                            | .00                                        | —                        |
|                        | <b>Results</b>           | <b>1869.33</b>  | <b>1875</b>         | <b>15</b>         | <b>25 43' 13.66</b>                | <b>+0.82</b>                               | —                        |

$$J = + 3^{\circ}.03071$$

$$L = - 20''.0125$$

$$K = - 0.01121$$

$$M = + 0.0371$$

$$P = + 0.013$$

$$N = + 0.16$$

| Right Ascen.<br>1875.<br>$\alpha$ | System-<br>atic Corr. | $\alpha + A$ .<br>$B_\alpha$ | Weight.    | $\Delta\mu_0(t-T_0)$<br>$F_\alpha$  | Corrected<br>R. A. 1875.<br>$B_\alpha' = B_\alpha + F_\alpha$ | $\alpha_0 - B_\alpha'$<br>$v_\alpha$ |
|-----------------------------------|-----------------------|------------------------------|------------|-------------------------------------|---------------------------------------------------------------|--------------------------------------|
| Declination<br>1875.<br>$\delta$  | $\Lambda$             | $\delta + A$ .<br>$B_\delta$ | $p$        | $\Delta\mu_0'(t-T_0)$<br>$F_\delta$ | Corrected<br>Decl. 1875.<br>$B_\delta' = B_\delta + F_\delta$ | $\delta_0 - B_\delta'$<br>$v_\delta$ |
| h m s                             | s                     | s                            |            | s                                   | s                                                             | s                                    |
| 12 14 48.624                      | +0.253                | 48.877                       | 0.1        | - 1.179                             | 47.698                                                        | +0.046                               |
| 14 47.952                         | +0.147                | 48.099                       | 1.0        | - 0.334                             | 47.765                                                        | -0.021                               |
| 14 47.450                         | +0.039                | 47.489                       | 0.6        | + 0.121                             | 47.610                                                        | +0.134                               |
| 14 47.610                         | +0.042                | 47.652                       | 1.0        | + 0.129                             | 47.781                                                        | -0.037                               |
| 14 47.520                         | .000                  | 47.520                       | 1.0        | + 0.250                             | 47.770                                                        | -0.026                               |
| h m s                             | s                     | s                            |            | s                                   | s                                                             | s                                    |
| <b>12 14 47.584</b>               | $\pm 0.0154$          | $\pm 0.0174$                 | <b>3.7</b> | - <b>0.0166</b>                     | $\pm 0.0008$                                                  | <b>1227</b>                          |
| 25 43 6.09                        | -2.69                 | 3.40                         | 0.1        | + 10.80                             | 14.20                                                         | -0.54                                |
| 43 11.70                          | -1.28                 | 10.42                        | 0.3        | + 3.74                              | 14.16                                                         | -0.50                                |
| 43 10.37                          | -1.59                 | 8.78                         | 0.3        | + 3.45                              | 12.23                                                         | +1.43                                |
| 43 14.90                          | -0.22                 | 14.68                        | 2.0        | - 0.54                              | 14.14                                                         | -0.48                                |
| 43 13.70                          | +0.28                 | 13.98                        | 0.6        | - 0.93                              | 13.05                                                         | +0.61                                |
| 43 14.90                          | .00                   | 14.90                        | 1.0        | - 1.59                              | 13.31                                                         | +0.35                                |
| 25 43 14.48                       | $\pm 0.193$           | $\pm 0.205$                  | <b>4.3</b> | + <b>0.144</b>                      | $\pm 0.0120$                                                  | <b>1114</b>                          |

7. B. D. 25°.2495 (11 CHASE).

$\alpha_{1875}$  12<sup>h</sup> 15<sup>m</sup> 9<sup>s</sup>.06  $\mu$ , 0<sup>s</sup>.000  
 $\delta_{1875}$  25° 41' 27".9  $\mu'$ , 0".00

| No. of Cat.<br>Sec. I. | Authority.               | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Right Asc.          | Corr. for<br>Errone's<br>Proper<br>Motion. | Reduction<br>to<br>1875. |
|------------------------|--------------------------|-----------------|---------------------|-------------------|---------------------|--------------------------------------------|--------------------------|
|                        |                          |                 |                     |                   | Declination         |                                            |                          |
|                        |                          |                 |                     |                   | at Epoch<br>of Cat. |                                            |                          |
|                        |                          | t               | T                   | n                 | h m s               | s                                          | m s                      |
| 3                      | Lalande 23132            | 1794.32         | 1800                | 1                 | 12 11 21.33         | 0.000                                      | +3 47.551                |
| 31                     | Cambr. An.               | 1842.34         | 1842                | 3                 | 13 29.36            | .000                                       | +1 40.043                |
| 31                     | " "                      | 1844.18         | 1844                | 1                 | 13 35.03            | .000                                       | +1 33.976                |
| 31                     | " "                      | 1845.25         | 1845                | 1                 | 13 38.01            | .000                                       | +1 30.943                |
| 26                     | Paris <sub>3</sub> 15120 | 1874.6          | 1875                | 3                 | 15 9.10             | .000                                       | —                        |
| 29                     | A. G. C. 6081            | 1877.7          | 1875                | 3                 | 15 9.06             | .000                                       | —                        |
|                        | Results                  | 1859.70         | 1875                | 12                | 12 15 9.167         | —0.049                                     | —                        |
| 3                      | Lalande 23132            | 1794.32         | 1800                | 1                 | 25 66' 33.0         | 0.00                                       | —25' 1.78                |
| 31                     | Cambr. An.               | 1842.37         | 1842                | 3                 | 52 28.46            | .00                                        | —11 0.55                 |
| 31                     | " "                      | 1843.36         | 1843                | 1                 | 52 10.52            | .00                                        | —10 40.53                |
| 31                     | " "                      | 1844.38         | 1844                | 2                 | 51 50.21            | .00                                        | —10 20.50                |
| 31                     | " "                      | 1845.34         | 1845                | 2                 | 51 30.59            | .00                                        | —10 0 48                 |
| 26                     | Paris <sub>3</sub> 15120 | 1874.6          | 1875                | 3                 | 41 28.4             | .00                                        | —                        |
| 29                     | A. G. C. 6081            | 1877.7          | 1875                | 3                 | 41 27.9             | .00                                        | —                        |
|                        | Results                  | 1856.23         | 1875                | 15                | 25 41' 27.93        | +0.08                                      | —                        |

$$J = +3^{\circ}.02976$$

$$L = -20''.0104$$

$$K = -0.01116$$

$$M = +0.0378$$

$$P = +0.013$$

$$N = +0.16$$

| Right Ascen.<br>1875.<br><b>a</b>       | System-<br>atic Corr. | $\alpha + A$<br><b>B<sub>a</sub></b> | Weight.    | $\Delta\mu_0(t-T_0)$<br><b>F<sub>a</sub></b>  | Corrected<br>R. A. 1875.<br><b>B<sub>a</sub>' = B<sub>a</sub> + F<sub>a</sub></b> | $\alpha_0 - B_{a'}$<br><b>v<sub>a</sub></b> |
|-----------------------------------------|-----------------------|--------------------------------------|------------|-----------------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------------|
| Declination<br>1875.<br><b>δ</b>        | <b>A</b>              | $\delta + A$<br><b>B<sub>δ</sub></b> | <b>p</b>   | $\Delta\mu_0'(t-T_0)$<br><b>F<sub>δ</sub></b> | Corrected<br>Decl. 1875.<br><b>B<sub>δ</sub>' = B<sub>δ</sub> + F<sub>δ</sub></b> | $\delta_0 - B_{δ'}$<br><b>v<sub>δ</sub></b> |
| <sup>h</sup> <sup>m</sup> <sup>s</sup>  | <sup>s</sup>          | <sup>s</sup>                         |            | <sup>s</sup>                                  | <sup>s</sup>                                                                      | <sup>s</sup>                                |
| 12 15 8.881                             | +0.253                | 9.134                                | 0.1        | -0.209                                        | 8.925                                                                             | +0.242                                      |
| 15 9.403                                | -0.075                | 9.328                                | 1.0        | -0.056                                        | 9.272                                                                             | -0.105                                      |
| 15 9.006                                | +0.147                | 9.153                                | 0.3        | -0.050                                        | 9.103                                                                             | +0.064                                      |
| 15 8.953                                | +0.147                | 9.100                                | 0.3        | -0.046                                        | 9.054                                                                             | +0.113                                      |
| 15 9.100                                | +0.042                | 9.142                                | 1.0        | +0.048                                        | 9.190                                                                             | -0.023                                      |
| 15 9.060                                | .000                  | 9.060                                | 1.0        | +0.058                                        | 9.118                                                                             | +0.049                                      |
| <sup>h</sup> <sup>m</sup> <sup>s</sup>  | <sup>s</sup>          | <sup>s</sup>                         |            | <sup>s</sup>                                  | <sup>s</sup>                                                                      |                                             |
| <b>12 15 9.118</b>                      | <b>±0.0154</b>        | <b>±0.0196</b>                       | <b>3.7</b> | <b>-0.0032</b>                                | <b>±0.0008</b>                                                                    | <b>1410</b>                                 |
| <sup>°</sup> <sup>'</sup> <sup>''</sup> | <sup>''</sup>         | <sup>''</sup>                        |            | <sup>''</sup>                                 | <sup>''</sup>                                                                     | <sup>''</sup>                               |
| 25 41 31.22                             | -2.69                 | 28.53                                | 0.1        | +0.25                                         | 28.78                                                                             | -0.85                                       |
| 41 27.91                                | -1.29                 | 26.62                                | 1.0        | +0.06                                         | 26.68                                                                             | +1.25                                       |
| 41 29.99                                | -1.28                 | 28.71                                | 0.3        | +0.05                                         | 28.76                                                                             | -0.83                                       |
| 41 29.71                                | -1.26                 | 28.45                                | 0.7        | +0.05                                         | 28.50                                                                             | -0.57                                       |
| 41 30.11                                | -1.59                 | 28.52                                | 0.7        | +0.04                                         | 28.56                                                                             | -0.63                                       |
| 41 28.40                                | -0.22                 | 28.18                                | 1.0        | -0.07                                         | 28.11                                                                             | -0.18                                       |
| 41 27.90                                | .00                   | 27.90                                | 1.0        | -0.09                                         | 27.81                                                                             | +0.12                                       |
| <b>25 41 28.01</b>                      | <b>±0.183</b>         | <b>±0.262</b>                        | <b>4.8</b> | <b>+0.004</b>                                 | <b>±0.0100</b>                                                                    | <b>1605</b>                                 |



## 8 B. D. 26°.2337 — 12e Comæ Berenices (d CHASE).—R. A.

$\alpha_{1875}$   $12^h$   $16^m$   $13^s.22$   $\mu, -0^s.0017$   
 $\delta_{1875}$   $26^\circ$   $32'$   $22''.7$   $\mu', +0''.006$

| No. of Cat.<br>Sec. I. | Authority.        | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Right Asc.<br>at Epoch<br>of Cat. | Corr. for<br>Errone's<br>Proper<br>Motion. | Reduction<br>to<br>1875. |
|------------------------|-------------------|-----------------|---------------------|-------------------|-----------------------------------|--------------------------------------------|--------------------------|
|                        |                   | t               | T                   | n                 | h m s                             | s                                          | m s                      |
| 1                      | Bradley 1658      | 1755.4          | 1755                | 4                 | 12 0 9.56                         | 0.000                                      | +6 3.656                 |
| 4                      | d'Agelet 2925     | 1784.38         | 1800                | 2                 | 12 26.20                          | -0.027                                     | +3 47.081                |
| 3                      | Lalande 23169     | 1794.31         | 1800                | 1                 | 12 25.85                          | -0.010                                     | +3 47.081                |
| 2                      | Piazzi 59         | 1800.68         | 1800                | 13                | 12 26.04                          | +0.001                                     | +3 47.081                |
| 6                      | S. Cat. Spec. 412 | 1823.74         | 1824                | 5                 | 13 38.83                          | -0.001                                     | +2 34.342                |
| 7                      | Pond 501          | 1831.07         | 1830                | 10                | 13 57.06                          | +0.001                                     | +2 16.168                |
| 8                      | Taylor 5673       | [1832.7]        | 1835                | 15                | 14 12.19                          | -0.004                                     | +2 1.026                 |
| 12                     | Paris, 15141      | 1840.0          | 1845                | 7                 | 14 42.43                          | -0.008                                     | +1 30.752                |
| 11                     | Gilliss 605       | 1840.29         | 1840                | 1                 | 14 27.039                         | .000                                       | +1 45.888                |
| 9                      | Rümker 3932       | [1841]          | 1836                | 3                 | 14 15.105                         | +0.008                                     | +1 57.998                |
| 32                     | Edinb. An.        | 1842.28         | 1842                | 3                 | 14 33.37                          | .000                                       | +1 39.833                |
| 16                     | Poulkova 1859     | 1842.32         | 1855                | 4                 | 15 12 64                          | .000                                       | +1 0.490                 |
| 10                     | Robinson 2658     | 1846.64         | 1840                | 4                 | 14 27.25                          | +0.011                                     | +1 45.888                |
| 18                     | Seven-Year 976    | 1859.3          | 1860                | 6                 | 15 27.86                          | -0.003                                     | + 45.363                 |
| 20                     | Yarnall 5253      | 1863.3          | 1860                | 3                 | 15 27.83                          | +0.006                                     | + 45.363                 |
| 19                     | Paris, 15141      | 1863.7          | 1860                | 21                | 15 27.79                          | +0.006                                     | + 45.363                 |
| 22                     | Safford 194       | 1865.41         | 1865                | 7                 | 15 43.016                         | +0.001                                     | + 30.239                 |
| 21                     | Bruxelles 5062    | 1871.37         | 1865                | 3                 | 15 42.91                          | +0.011                                     | + 30.239                 |
| 27                     | Rogers 533        | 1873.7          | 1875                | 16                | 16 13.233                         | .000                                       | —                        |
| 26                     | Paris, 15141      | 1874.6          | 1875                | 4                 | 16 13.21                          | -0.001                                     | —                        |
| 25                     | Romberg 2741      | 1874.9          | 1875                | 8                 | 16 13.20                          | .000                                       | —                        |
| 23                     | Nine-Year 1140    | 1875.3          | 1872                | 3                 | 16 4.145                          | -0.001                                     | + 9.070                  |
| 34                     | Madras An. 466    | 1878.34         | 1878                | 2                 | 16 22.33                          | +0.001                                     | — 9.070                  |
| 30                     | Ten-Year 1933     | 1878.81         | 1880                | 4                 | 16 28.309                         | .000                                       | — 15.115                 |
| 34                     | Madras An. 539    | 1879.28         | 1879                | 3                 | 16 25 07                          | .000                                       | — 12.092                 |
| 29                     | A. G. C. 6089     | 1880.0          | 1875                | 3                 | 16 13.22                          | +0.008                                     | —                        |
| 35                     | Green, An. 777    | 1888.32         | 1888                | 3                 | 16 52.493                         | .000                                       | — 39.294                 |
| 35                     | " " 1552          | 1894.45         | 1894                | 3                 | 17 10.560                         | .000                                       | — 57.422                 |
|                        | Results           | 1859.97         | 1875                | 161               | 12 16 13.210                      | -0.008                                     | —                        |

$$J = + 3''.02333$$

$$L = - 19''.9980$$

$$K = - 0.01158$$

$$M = + 0.0398$$

$$P = + 0.013$$

$$N = + 0.16$$

| Right Asc.<br>1875.<br>$\alpha$ | System-<br>atic Corr.<br>$A$ | $a + A$ .<br>$B_a$ | Weight.<br>$p$ | $\Delta\mu_0(t-T_0)$<br>$F_a$ | Corrected<br>R. A. 1875.<br>$B_a' = B_a + F_a$ | $a_0 - B_a'$<br>$v_a$ |
|---------------------------------|------------------------------|--------------------|----------------|-------------------------------|------------------------------------------------|-----------------------|
| h m s                           | s                            | s                  |                | s                             | s                                              | s                     |
| 12 16 13.216                    | 0.000                        | 13.216             | 0.5            | -0.052                        | 13.164                                         | +0.046                |
| 16 13.254                       | +0.332                       | 13.586             | 0.2            | -0.038                        | 13.548                                         | -0.338                |
| 16 12.921                       | +0.253                       | 13.174             | 0.1            | -0.033                        | 13.141                                         | +0.069                |
| 16 13.122                       | +0.253                       | 13.375             | 0.3            | -0.030                        | 13.345                                         | -0.135                |
| 16 13.171                       | +0.044                       | 13.215             | 2.0            | -0.018                        | 13.197                                         | +0.013                |
| 16 13.229                       | -0.017                       | 13.212             | 1.0            | -0.014                        | 13.198                                         | +0.012                |
| 16 13.212                       | -0.058                       | 13.154             | 0.5            | -0.014                        | 13.140                                         | +0.070                |
| 16 13.174                       | +0.047                       | 13.221             | 2.0            | -0.010                        | 13.211                                         | -0.001                |
| 16 12.927                       | -0.049                       | 12.878             | 0.1            | -0.010                        | 12.868                                         | +0.342                |
| 16 13.111                       | +0.037                       | 13.148             | 0.3            | -0.009                        | 13.139                                         | +0.071                |
| 16 13.203                       | -0.012                       | 13.191             | 0.3            | -0.009                        | 13.182                                         | +0.028                |
| 16 13.130                       | +0.059                       | 13.189             | 2.0            | -0.009                        | 13.180                                         | +0.030                |
| 16 13.149                       | +0.068                       | 13.217             | 0.3            | -0.007                        | 13.210                                         | .000                  |
| 16 13.220                       | -0.013                       | 13.207             | 2.0            | .000                          | 13.207                                         | +0.003                |
| 16 13.199                       | +0.032                       | 13.231             | 0.6            | +0.002                        | 13.233                                         | -0.023                |
| 16 13.159                       | +0.051                       | 13.210             | 3.0            | +0.002                        | 13.212                                         | -0.002                |
| 16 13.256                       | +0.006                       | 13.262             | 2.0            | +0.003                        | 13.265                                         | -0.055                |
| 16 13.160                       | +0.044                       | 13.204             | 1.0            | +0.006                        | 13.210                                         | .000                  |
| 16 13.233                       | +0.004                       | 13.237             | 3.0            | +0.007                        | 13.244                                         | -0.034                |
| 16 13.209                       | +0.042                       | 13.251             | 1.0            | +0.007                        | 13.258                                         | -0.048                |
| 16 13.200                       | -0.003                       | 13.197             | 4.0            | +0.007                        | 13.204                                         | +0.006                |
| 16 13.214                       | +0.006                       | 13.220             | 1.0            | +0.008                        | 13.228                                         | -0.018                |
| 16 13.261                       | +0.018                       | 13.279             | 0.7            | +0.009                        | 13.288                                         | -0.078                |
| 16 13.194                       | +0.010                       | 13.204             | 1.0            | +0.009                        | 13.213                                         | -0.003                |
| 16 12.978                       | +0.018                       | 12.996             | 1.0            | +0.010                        | 13.006                                         | +0.204                |
| 16 13.228                       | .000                         | 13.228             | 1.0            | +0.010                        | 13.238                                         | -0.028                |
| 16 13.199                       | +0.010                       | 13.209             | 1.0            | +0.014                        | 13.223                                         | -0.013                |
| 16 13.138                       | +0.010                       | 13.148             | 1.0            | +0.017                        | 13.165                                         | +0.045                |
| h m s                           | s                            | s                  |                | s                             | s                                              | s                     |
| 12 16 13.202                    | $\pm 0.0052$                 | $\pm 0.0062$       | 32.9           | -0.0022                       | $\pm 0.0002$                                   | 19151                 |

## 8 B. D. 26°.2337 — 12e Comæ Berenices (d CHASE).—Decl.

$$\begin{array}{rcccl} \alpha_{1875} & 12^h & 16^m & 13^s.22 & \mu, -0^s.0017 \\ \delta_{1875} & 26^\circ & 32' & 22''.7 & \mu, +0''.006 \end{array}$$

| No. of Cat.<br>Sec. I. | * Authority.      | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Declination<br>at Epoch<br>of Cat. | Corr. for<br>Errone's<br>Proper<br>Motion. | Reduction<br>to<br>1875. |
|------------------------|-------------------|-----------------|---------------------|-------------------|------------------------------------|--------------------------------------------|--------------------------|
|                        |                   | t               | T                   | n                 |                                    |                                            |                          |
| 1                      | Bradley 1658      | 1754.3          | 1755                | 3                 | 26° 72' 26.8                       | 0.00                                       | —40' 2.35                |
| 4                      | d'Agelet 2925     | 1784.38         | 1800                | 2                 | 57 26.2                            | +0.09                                      | —25 0.90                 |
| 3                      | Lalande 23169     | 1794.31         | 1800                | 1                 | 57 27.1                            | +0.03                                      | —25 0.90                 |
| 2                      | Piazzi 59         | 1800.68         | 1800                | 16                | 57 25.5                            | .00                                        | —25 0.90                 |
| 6                      | Σ. Cat. Spec. 412 | 1823.74         | 1824                | 5                 | 49 24.6                            | .00                                        | —17 0.39                 |
| 7                      | Pond 501          | 1831.53         | 1830                | 12                | 47 25.9                            | —0.01                                      | —15 0.30                 |
| 8                      | Taylor 5673       | [1831.9]        | 1835                | 5                 | 45 44.34                           | +0.02                                      | —13 20.23                |
| 12                     | Paris, 15141      | 1838.8          | 1845                | 2                 | 42 25.9                            | +0.04                                      | —10 0.12                 |
| 9                      | Rümker 3932       | [1841]          | 1836                | 3                 | 45 24.34                           | —0.03                                      | —13 0.22                 |
| 32                     | Edinb. An.        | 1842.28         | 1842                | 3                 | 43 25.1                            | .00                                        | —11 0.15                 |
| 16                     | Poulkova 1859     | 1842.32         | 1855                | 4                 | 39 4.6                             | .00                                        | —6 40.04                 |
| 10                     | Robinson 2658     | 1853.2          | 1840                | 3                 | 44 4.37                            | —0.08                                      | —11 40.17                |
| 18                     | Seven-Year 976    | 1859.3          | 1860                | 6                 | 37 24.40                           | .00                                        | —5 0.02                  |
| 21                     | Bruxelles 5062    | 1868.31         | 1865                | 1                 | 35 44.46                           | —0.02                                      | —3 20.00                 |
| 20                     | Yarnall 5253      | 1872.2          | 1860                | 4                 | 37 25.9                            | —0.07                                      | —5 0.02                  |
| 27                     | Rogers 533        | 1873.7          | 1875                | 16                | 32 24.01                           | .00                                        | —                        |
| 23                     | Nine Year 1140    | 1874.4          | 1872                | 11                | 33 24.18                           | —0.01                                      | —1 0.00                  |
| 26                     | Paris, 15141      | 1874.6          | 1875                | 4                 | 32 23.8                            | .00                                        | —                        |
| 25                     | Romberg 2741      | 1874.9          | 1875                | 8                 | 32 24.3                            | .00                                        | —                        |
| 28                     | Respighi 684      | 1875.76         | 1875                | 26                | 32 23.84                           | .00                                        | —                        |
| 34                     | Madras An. 466    | 1878.34         | 1878                | 2                 | 31 23.5                            | .00                                        | + 59.99                  |
| 34                     | “ “ 539           | 1879.28         | 1879                | 3                 | 31 4.4                             | .00                                        | + 1 19.99                |
| 30                     | Ten-Year 1933     | 1879.63         | 1880                | 17                | 30 44.14                           | .00                                        | + 1 39.98                |
| 29                     | A. G. C. 6089     | 1880.0          | 1875                | 3                 | 32 22.7                            | —0.03                                      | —                        |
| 35                     | Green. An. 777    | 1888.32         | 1888                | 6                 | 28 3.56                            | .00                                        | + 4 19.94                |
| 35                     | “ “ 1552          | 1894.39         | 1894                | 5                 | 26 3.60                            | .00                                        | + 6 19.89                |
|                        | Results           | 1865.03         | 1875                | 171               | 26° 32' 23.97                      | +0.01                                      | —                        |

$$J = + 3^{\circ}.02333$$

$$L = - 19''.9980$$

$$K = - 0.01158$$

$$M = + 0.0398$$

$$P = + 0.013$$

$$N = + 0.16$$

| Declination<br>1875.<br>$\delta$ | System-<br>atic Corr.<br>$\Lambda$ | $\delta + A$<br>$B_{\delta}$ | Weight.<br>$p$ | $\Delta\mu_0'(t-T_0)$<br>$F_{\delta}$ | Corrected<br>Decl. 1875.<br>$B_{\delta}' = B_{\delta} + F_{\delta}$ | $\delta_0 - B_{\delta}'$<br>$V_{\delta}$ |
|----------------------------------|------------------------------------|------------------------------|----------------|---------------------------------------|---------------------------------------------------------------------|------------------------------------------|
| 26° 32' 24.45                    | "                                  | 24.45                        | 0.4            | +0.11                                 | 24.56                                                               | -0.59                                    |
| 32 25.39                         | -1.41                              | 23.98                        | 0.2            | +0.08                                 | 24.06                                                               | -0.09                                    |
| 32 26.23                         | -2.63                              | 23.60                        | 0.1            | +0.07                                 | 23.67                                                               | +0.30                                    |
| 32 24.60                         | -2.63                              | 21.97                        | 0.3            | +0.06                                 | 22.03                                                               | +1.94                                    |
| 32 24.21                         | -1.04                              | 23.17                        | 2.0            | +0.04                                 | 23.21                                                               | +0.76                                    |
| 32 25.59                         | -1.90                              | 23.69                        | 1.0            | +0.03                                 | 23.72                                                               | +0.25                                    |
| 32 24.13                         | -0.84                              | 23.29                        | 0.5            | +0.03                                 | 23.32                                                               | +0.65                                    |
| 32 25.82                         | -0.45                              | 25.37                        | 0.7            | +0.03                                 | 25.40                                                               | -1.43                                    |
| 32 24.09                         | -0.30                              | 23.79                        | 0.3            | +0.02                                 | 23.81                                                               | +0.16                                    |
| 32 24.95                         | -1.12                              | 23.83                        | 0.3            | +0.02                                 | 23.85                                                               | +0.12                                    |
| 32 24.56                         | -0.02                              | 24.54                        | 2.0            | +0.02                                 | 24.56                                                               | -0.59                                    |
| 32 24.12                         | -0.82                              | 23.30                        | 0.3            | +0.01                                 | 23.31                                                               | +0.66                                    |
| 32 24.38                         | -0.09                              | 24.29                        | 2.0            | +0.01                                 | 24.30                                                               | -0.33                                    |
| 32 24.44                         | -0.03                              | 24.41                        | 0.3            | .00                                   | 24.41                                                               | -0.44                                    |
| 32 25.81                         | -0.11                              | 25.70                        | 0.6            | -0.01                                 | 25.69                                                               | -1.72                                    |
| 32 24.01                         | +0.26                              | 24.27                        | 3.0            | -0.01                                 | 24.26                                                               | -0.29                                    |
| 32 21.17                         | -0.46                              | 23.71                        | 3.0            | -0.01                                 | 23.70                                                               | +0.27                                    |
| 32 23.80                         | -0.22                              | 23.58                        | 1.0            | -0.01                                 | 23.57                                                               | +0.40                                    |
| 32 24.30                         | .00                                | 24.30                        | 4.0            | -0.01                                 | 24.29                                                               | -0.32                                    |
| 32 23.84                         | +0.41                              | 24.25                        | 1.5            | -0.01                                 | 24.24                                                               | -0.27                                    |
| 32 23.49                         | -0.29                              | 23.20                        | 0.7            | -0.01                                 | 23.19                                                               | +0.78                                    |
| 32 24.39                         | -0.29                              | 24.10                        | 1.0            | -0.01                                 | 24.09                                                               | -0.12                                    |
| 32 24.12                         | +0.08                              | 24.20                        | 3.0            | -0.01                                 | 24.19                                                               | -0.22                                    |
| 32 22.67                         | .00                                | 22.67                        | 1.0            | -0.01                                 | 22.66                                                               | +1.31                                    |
| 32 23.50                         | +0.09                              | 23.59                        | 2.0            | -0.02                                 | 23.57                                                               | +0.40                                    |
| 32 23.49                         | +0.09                              | 23.58                        | 2.0            | -0.03                                 | 23.55                                                               | +0.42                                    |
| 26 32 23.98                      | $\pm 0.069$                        | $\pm 0.074$                  | 33.2           | +0.007                                | $\pm 0.0028$                                                        | 20154                                    |

## 9 B. D. 26°.2338 (14 CHASE).

$$\begin{array}{rclclcl} \alpha_{1875} & 12^h & 16^m & 14^s.37 & \mu, & 0^s.000 \\ \delta_{1875} & 26^\circ & 31' & 20''.5 & \mu', & 0''.00 \end{array}$$

| No. of Cat.<br>Sec. I. | Authority.      | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Right Asc.<br>at Epoch<br>of Cat.  | Corr. for<br>Errone's<br>Proper<br>Motion. | Reduction<br>to<br>1875. |
|------------------------|-----------------|-----------------|---------------------|-------------------|------------------------------------|--------------------------------------------|--------------------------|
|                        |                 |                 |                     |                   | Declination<br>at Epoch<br>of Cat. |                                            |                          |
|                        |                 | t               | T                   | n                 | h m s                              | s                                          | m s                      |
| 17                     | Argelander 2338 | 1858.22         | 1855                | 1                 | 12 15 13.77                        | 0.000                                      | +1 0.523                 |
| 21                     | Bruxelles 5063  | 1871.37         | 1865                | 3                 | 15 43.96                           | .000                                       | + 30.256                 |
| 29                     | A. G. C. 6090   | 1877.3          | 1875                | 3                 | 16 14.37                           | .000                                       | —                        |
| 25                     | Romberg 2742    | 1877.6          | 1875                | 4                 | 16 14.27                           | .000                                       | —                        |
|                        | <b>Results</b>  | <b>1875.12</b>  | <b>1875</b>         | <b>11</b>         | <b>12 16 14.293</b>                | <b>0.000</b>                               | <b>—</b>                 |
| 10                     | Robinson 2659   | 1853.68         | 1840                | 2                 | 26 42 59 48                        | 0.00                                       | —11 40.38                |
| 17                     | Argelander 2338 | 1858.22         | 1855                | 1                 | 37 59 4                            | .00                                        | — 6 40.16                |
| 21                     | Bruxelles 5063  | 1868.31         | 1865                | 1                 | 34 40.58                           | .00                                        | — 3 20.06                |
| 29                     | A. G. C. 6090   | 1877.3          | 1875                | 3                 | 31 20.5                            | .00                                        | —                        |
| 25                     | Romberg 2742    | 1877.6          | 1875                | 4                 | 31 20.4                            | .00                                        | —                        |
|                        | <b>Results</b>  | <b>1874.43</b>  | <b>1875</b>         | <b>11</b>         | <b>26 31 20.21</b>                 | <b>+0.05</b>                               | <b>—</b>                 |

$$J = + 3^{\circ}.02501$$

$$L = - 20''.0039$$

$$K = - 0.01157$$

$$M = + 0.0398$$

$$P = + 0.013$$

$$N = + 0.16$$

| Right Asc.<br>1875.<br>$\alpha$                        | System-<br>atic Corr.        | $\alpha + A$<br>$B_\alpha$   | Weight. | $\Delta\mu_0(t-T_0)$<br>$F_\alpha$  | Corrected<br>R. A. 1875.<br>$B_\alpha' = B_\alpha + F_\alpha$ | $\alpha_0 - B_\alpha'$<br>$V_\alpha$ |
|--------------------------------------------------------|------------------------------|------------------------------|---------|-------------------------------------|---------------------------------------------------------------|--------------------------------------|
| Declination<br>1875.<br>$\delta$                       | $\delta + A$<br>$B_\delta$   | $\delta + A$<br>$B_\delta$   | $p$     | $\Delta\mu_0'(t-T_0)$<br>$F_\delta$ | Corrected<br>Decl. 1875.<br>$B_\delta' = B_\delta + F_\delta$ | $\delta_0 - B_\delta'$<br>$V_\delta$ |
| <sup>h</sup> <sup>m</sup> <sup>s</sup>                 | <sup>s</sup>                 | <sup>s</sup>                 |         | <sup>s</sup>                        | <sup>s</sup>                                                  | <sup>s</sup>                         |
| 12 16 14.293                                           | +0.037                       | 14.330                       | 0.2     | +0.007                              | 14.337                                                        | -0.044                               |
| 16 14.216                                              | +0.044                       | 14.260                       | 1.0     | +0.002                              | 14.262                                                        | +0.031                               |
| 16 14.370                                              | .000                         | 14.370                       | 1.0     | -0.001                              | 14.369                                                        | -0.076                               |
| 16 14.270                                              | -0.003                       | 14.267                       | 2.0     | -0.001                              | 14.266                                                        | +0.027                               |
| <sup>h</sup> <sup>m</sup> <sup>s</sup><br>12 16 14.293 | <sup>s</sup><br>$\pm 0.0146$ | <sup>s</sup><br>$\pm 0.0146$ | 4.2     | <sup>s</sup><br>+0.0004             | <sup>s</sup><br>$\pm 0.0032$                                  | <sup>s</sup><br>88                   |
| <sup>h</sup> <sup>m</sup> <sup>s</sup><br>26 31 19.10  | -0.82                        | 18.28                        | 0.2     | +1.83                               | 20.11                                                         | +0.10                                |
| 31 19.24                                               | -0.94                        | 18.30                        | 0.2     | +1.43                               | 19.73                                                         | +0.48                                |
| 31 20.52                                               | -0.03                        | 20.49                        | 0.3     | +0.54                               | 21.03                                                         | -0.82                                |
| 31 20.50                                               | .00                          | 20.50                        | 1.0     | -0.25                               | 20.25                                                         | -0.04                                |
| 31 20.40                                               | .00                          | 20.40                        | 2.0     | -0.28                               | 20.12                                                         | +0.09                                |
| 26 31 20.26                                            | $\pm 0.208$                  | $\pm 0.209$                  | 3.7     | +0.088                              | $\pm 0.0300$                                                  | 178                                  |



## 10 B. D. 26° 2313 (18 CHASE).

$\alpha_{1875}$        $12^h$        $17^m$        $46^s.97$        $\mu, 0^s.000$   
 $\delta_{1875}$        $26^\circ$        $32'$        $40''6$        $\mu', 0''.00$

| No. of Cat.<br>Sec. I. | Authority.                    | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Right Asc.                         |       |        | Corr. for<br>Errone's<br>Proper<br>Motion. | Reduction<br>to<br>1875. |        |
|------------------------|-------------------------------|-----------------|---------------------|-------------------|------------------------------------|-------|--------|--------------------------------------------|--------------------------|--------|
|                        |                               |                 |                     |                   | at Epoch<br>of Cat.                |       |        |                                            |                          |        |
|                        |                               |                 |                     |                   | Declination<br>at Epoch<br>of Cat. |       |        |                                            |                          |        |
|                        |                               | t               | T                   | n                 | h                                  | m     | s      | s                                          | m                        | s      |
| 3                      | Lalande 23207                 | 1794.31         | 1800                | 1                 | 12                                 | 14    | 0.18   | 0.000                                      | +3                       | 46.864 |
| 2                      | Piazzi 68                     | 1804.46         | 1800                | 8                 | 13                                 | 59.90 | .000   | +3                                         | 46.864                   |        |
| 5                      | Bessel (W <sub>1</sub> .) 348 | 1831.31         | 1825                | 1                 | 15                                 | 15.38 | .000   | +2                                         | 31.169                   |        |
| 12                     | Paris <sub>1</sub> 15178      | 1838.9          | 1845                | 3                 | 16                                 | 16.30 | .000   | +1                                         | 30.666                   |        |
| 8                      | Taylor 5688                   | [1839.8]        | 1835                | 6                 | 15                                 | 46.16 | .000   | +2                                         | 0.911                    |        |
| 10                     | Robinson 2663                 | 1848.35         | 1840                | 1                 | 16                                 | 1.30  | .000   | +1                                         | 45.787                   |        |
| 33                     | Radcl. An. 750                | 1868.36         | 1868                | 2                 | 17                                 | 25.86 | .000   | +21                                        | 146                      |        |
| 21                     | Bruxelles 5068                | 1869.87         | 1865                | 2                 | 17                                 | 16.72 | .000   | +30                                        | 210                      |        |
| 33                     | Radcl. An. 595                | 1871.36         | 1871                | 2                 | 17                                 | 34.88 | .000   | +12                                        | 083                      |        |
| 26                     | Paris <sub>3</sub> 15178      | 1872.7          | 1875                | 5                 | 17                                 | 46.97 | .000   | —                                          | —                        |        |
| 20                     | Yarnall 5268                  | 1876.0          | 1860                | 3                 | 17                                 | 1.60  | .000   | +45                                        | 320                      |        |
| 29                     | A. G. C. 6100                 | 1878.3          | 1875                | 4                 | 17                                 | 46.97 | .000   | —                                          | —                        |        |
| 25                     | Romberg 2751                  | 1878.4          | 1875                | 4                 | 17                                 | 46.85 | .000   | —                                          | —                        |        |
| Results                |                               |                 |                     |                   | h                                  | m     | s      | s                                          |                          |        |
|                        |                               |                 |                     |                   | 12                                 | 17    | 46.965 | —0.020                                     | —                        |        |
| 3                      | Lalande 23207                 | 1794.31         | 1800                | 1                 | 26                                 | 57    | 41.3   | 0.00                                       | —25                      | 0.68   |
| 2                      | Piazzi 68                     | 1804.46         | 1800                | 9                 | 57                                 | 42.2  | .00    | —25                                        | 0.68                     |        |
| 5                      | Bessel (W <sub>1</sub> .) 348 | 1831.31         | 1825                | 1                 | 49                                 | 16.6  | .00    | —16                                        | 40.21                    |        |
| 8                      | Taylor 5688                   | [1838.8]        | 1835                | 8                 | 46                                 | 1.09  | .00    | —13                                        | 20.09                    |        |
| 10                     | Robinson 2663                 | 1853.04         | 1840                | 5                 | 44                                 | 21.84 | .00    | —11                                        | 40.05                    |        |
| 33                     | Radcl. An. 642                | 1864.31         | 1861                | 2                 | 36                                 | 21.81 | .00    | —3                                         | 39.96                    |        |
| 33                     | " " 750                       | 1868.30         | 1868                | 1                 | 34                                 | 58.53 | .00    | —2                                         | 19.97                    |        |
| 21                     | Bruxelles 5068                | 1868.31         | 1865                | 1                 | 36                                 | 1.48  | .00    | —3                                         | 19.96                    |        |
| 33                     | Radcl. An. 571                | 1869.30         | 1869                | 2                 | 34                                 | 40.53 | .00    | —1                                         | 59.97                    |        |
| 33                     | " " 595                       | 1871.36         | 1871                | 2                 | 34                                 | 1.30  | .00    | —1                                         | 19.98                    |        |
| 26                     | Paris <sub>3</sub> 15178      | 1872.7          | 1875                | 5                 | 32                                 | 41.5  | .00    | —                                          | —                        |        |
| 33                     | Radcl. An. 714                | 1874.23         | 1874                | 2                 | 32                                 | 59.55 | .00    | —                                          | 19.99                    |        |
| 20                     | Yarnall 5268                  | 1876.4          | 1860                | 2                 | 37                                 | 41.1  | .00    | —4                                         | 59.96                    |        |
| 29                     | A. G. C. 6100                 | 1878.3          | 1875                | 4                 | 32                                 | 40.6  | .00    | —                                          | —                        |        |
| 25                     | Romberg 2751                  | 1878.4          | 1875                | 4                 | 32                                 | 40.7  | .00    | —                                          | —                        |        |
| Results                |                               |                 |                     |                   | 26                                 | 32    | 40.61  | +0.11                                      | —                        |        |

$$J = +3^{\circ}.02048$$

$$L = -19''.9939$$

$$K = -0.01145$$

$$M = +0.0427$$

$$P = +0.013$$

$$N = +0.16$$

| Right Ascen.<br>1875. |     | System-<br>atic Corr. | $a + A.$<br>$B_a$           |              | Weight. | $\Delta\mu_0(t-T_0).$<br>$F_a$       |  | Corrected<br>R. A. 1875.<br>$B_a' = B_a + F_a$                |  | $\alpha_0 - B_a'$<br>$v_a$           |  |
|-----------------------|-----|-----------------------|-----------------------------|--------------|---------|--------------------------------------|--|---------------------------------------------------------------|--|--------------------------------------|--|
| Declination<br>1875.  |     |                       | $\delta + A.$<br>$B_\delta$ |              |         | $\Delta\mu_0'(t-T_0).$<br>$F_\delta$ |  | Corrected<br>Decl. 1875.<br>$B_\delta' = B_\delta + F_\delta$ |  | $\delta_0 - B_\delta'$<br>$v_\delta$ |  |
| $\delta$              |     | $A$                   | $p$                         |              |         | $s$                                  |  | $s$                                                           |  | $s$                                  |  |
| h                     | m s | s                     | s                           |              |         | s                                    |  | s                                                             |  | s                                    |  |
| 12                    | 17  | 47.044                | 0.253                       | 47.297       | 0.1     | -0.142                               |  | 47.155                                                        |  | -0.190                               |  |
|                       | 17  | 46.764                | 0.253                       | 47.017       | 0.3     | -0.121                               |  | 46.896                                                        |  | +0.069                               |  |
|                       | 17  | 46.549                | 0.122                       | 46.671       | 0.1     | -0.068                               |  | 46.603                                                        |  | +0.362                               |  |
|                       | 17  | 46.966                | 0.047                       | 47.013       | 1.0     | -0.052                               |  | 46.961                                                        |  | +0.004                               |  |
|                       | 17  | 47.071                | -0.058                      | 47.013       | 0.5     | -0.051                               |  | 46.962                                                        |  | +0.003                               |  |
|                       | 17  | 47.087                | 0.068                       | 47.155       | 0.1     | -0.034                               |  | 47.121                                                        |  | -0.156                               |  |
|                       | 17  | 47.006                | 0.033                       | 47.039       | 0.5     | +0.006                               |  | 47.045                                                        |  | -0.080                               |  |
|                       | 17  | 46.930                | 0.044                       | 46.974       | 0.7     | +0.009                               |  | 46.983                                                        |  | -0.018                               |  |
|                       | 17  | 46.963                | -0.020                      | 46.943       | 0.5     | +0.012                               |  | 46.955                                                        |  | +0.010                               |  |
|                       | 17  | 46.970                | 0.042                       | 47.012       | 2.0     | +0.015                               |  | 47.027                                                        |  | -0.062                               |  |
|                       | 17  | 46.920                | 0.031                       | 46.951       | 0.6     | +0.022                               |  | 46.973                                                        |  | -0.008                               |  |
|                       | 17  | 46.970                | .000                        | 46.970       | 1.0     | +0.026                               |  | 46.996                                                        |  | -0.031                               |  |
|                       | 17  | 46.850                | -0.003                      | 46.847       | 2.0     | +0.026                               |  | 46.873                                                        |  | +0.092                               |  |
| h                     | m s | s                     | s                           |              |         | s                                    |  | s                                                             |  | s                                    |  |
| 12                    | 17  | 46.915                | 0.0097                      | $\pm 0.0109$ | 9.4     | -0.0020                              |  | $\pm 0.0005$                                                  |  | 3509                                 |  |
| 26                    | 32  | 43.62                 | -2.62                       | 41.00        | 0.1     | +1.10                                |  | 42.10                                                         |  | -1.49                                |  |
|                       | 32  | 41.52                 | -2.62                       | 38.90        | 0.3     | +0.95                                |  | 39.85                                                         |  | +0.76                                |  |
|                       | 32  | 36.39                 | -3.15                       | 39.54        | 0.1     | +0.55                                |  | 40.09                                                         |  | +0.52                                |  |
|                       | 32  | 41.00                 | -0.83                       | 40.17        | 0.5     | +0.43                                |  | 40.60                                                         |  | +0.01                                |  |
|                       | 32  | 41.79                 | -0.82                       | 40.97        | 0.5     | +0.22                                |  | 41.19                                                         |  | -0.58                                |  |
|                       | 32  | 41.85                 | -0.82                       | 41.03        | 0.5     | +0.05                                |  | 41.08                                                         |  | -0.47                                |  |
|                       | 32  | 38.56                 | +0.02                       | 38.58        | 0.5     | -0.01                                |  | 38.57                                                         |  | +2.04                                |  |
|                       | 32  | 41.52                 | -0.03                       | 41.49        | 0.3     | -0.01                                |  | 41.48                                                         |  | -0.87                                |  |
|                       | 32  | 40.56                 | -0.40                       | 40.16        | 0.5     | -0.02                                |  | 40.14                                                         |  | +0.47                                |  |
|                       | 32  | 41.32                 | -0.31                       | 41.01        | 0.5     | -0.05                                |  | 40.96                                                         |  | -0.35                                |  |
|                       | 32  | 41.50                 | -0.22                       | 41.28        | 2.0     | -0.07                                |  | 41.21                                                         |  | -0.60                                |  |
|                       | 32  | 39.56                 | -0.03                       | 39.53        | 0.5     | -0.10                                |  | 39.43                                                         |  | +1.18                                |  |
|                       | 32  | 41.14                 | -0.09                       | 41.05        | 0.6     | -0.13                                |  | 40.92                                                         |  | -0.31                                |  |
|                       | 32  | 40.60                 | .00                         | 40.60        | 1.0     | -0.16                                |  | 40.44                                                         |  | +0.17                                |  |
|                       | 32  | 40.70                 | .00                         | 40.70        | 2.0     | -0.16                                |  | 40.54                                                         |  | +0.07                                |  |
| 26                    | 32  | 40.72                 | -0.127                      | $\pm 0.138$  | 9.9     | +0.015                               |  | $\pm 0.0075$                                                  |  | 2868                                 |  |

## 11 B. D. 26°.2344—13f Comæ Berenices (19 CHASE).

$\alpha_{1875}$   $12^h$   $18^m$   $2^s.16$   $\mu, -0^s.0020$   
 $\delta_{1875}$   $26^\circ$   $47'$   $30''.3$   $\mu', -0''.021$

| No. of Cat.<br>Sec. I. | Authority.                   | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Right Asc.                         |        | Corr. for<br>Errone's<br>Proper<br>Motion | Reduction<br>to<br>1875. |
|------------------------|------------------------------|-----------------|---------------------|-------------------|------------------------------------|--------|-------------------------------------------|--------------------------|
|                        |                              |                 |                     |                   | at Epoch<br>of Cat.                |        |                                           |                          |
|                        |                              |                 |                     |                   | Declination<br>at Epoch<br>of Cat. |        |                                           |                          |
|                        |                              | t               | T                   | n                 | h m s                              | s      | m s                                       |                          |
| 1                      | Bradley 1661                 | 1755.8          | 1755                | 6                 | 12 11 59.35                        | 0.000  | +6                                        | 2.918                    |
| 4                      | d'Agelet 293I                | 1783.37         | 1800                | 2                 | 14 15.15                           | -0.033 | +3                                        | 46.620                   |
| 3                      | Lalande 232II                | 1794.31         | 1800                | 1                 | 14 15.25                           | -0.011 | +3                                        | 46.620                   |
| 2                      | Piazzi 70                    | 1801.28         | 1800                | 7                 | 14 15.18                           | +0.003 | +3                                        | 46.620                   |
| 5                      | Bessel (W <sub>1</sub> ) 35I | 1830.32         | 1825                | 2                 | 15 31.10                           | +0.011 | +2                                        | 31.005                   |
| 7                      | Pond 502                     | 1831.67         | 1830                | 6                 | 15 46.49                           | +0.003 | +2                                        | 15.891                   |
| 8                      | Taylor 569I                  | [1832.3]        | 1835                | 12                | 16 1.42                            | -0.005 | +2                                        | 0.780                    |
| 10                     | Robinson 2665                | 1836.05         | 1840                | 7                 | 16 16.44                           | -0.008 | +1                                        | 45.672                   |
| 12                     | Paris, 15182                 | 1838.0          | 1845                | 9                 | 16 31.57                           | -0.014 | +1                                        | 30.567                   |
| 11                     | Gilliss 608                  | 1840.79         | 1840                | 13                | 16 16.470                          | +0.002 | +1                                        | 45.672                   |
| 9                      | Rümker 3950                  | [1841]          | 1836                | 7                 | 16 4.359                           | +0.010 | +1                                        | 30.758                   |
| 16                     | Poulkova 1862                | 1841.34         | 1855                | 4                 | 17 1.82                            | .000   | +1                                        | 0.367                    |
| 32                     | Edinb. An.                   | 1842.28         | 1842                | 3                 | 16 22.55                           | +0.001 | +1                                        | 39.630                   |
| 18                     | Seven-Year 977               | 1854.3          | 1860                | 3                 | 17 17.01                           | -0.017 | +45                                       | 271                      |
| 19                     | Paris, 15182                 | 1859.8          | 1860                | 2                 | 17 16.80                           | .000   | +45                                       | 271                      |
| 21                     | Bruxelles 5072               | 1861.96         | 1865                | 3                 | 17 31.97                           | -0.006 | +30                                       | 178                      |
| 22                     | Safford 195                  | 1865.41         | 1865                | 6                 | 17 32.035                          | +0.001 | +30                                       | 178                      |
| 27                     | Rogers 534                   | 1872.6          | 1875                | 12                | 18 2.181                           | +0.001 | —                                         | —                        |
| 34                     | Madras An. 468               | 1878.39         | 1878                | 3                 | 18 11.08                           | +0.001 | —                                         | 9.051                    |
| 25                     | Romberg 2754                 | 1878.4          | 1875                | 4                 | 18 2.16                            | .000   | —                                         | —                        |
| 29                     | A. G. C. 6102                | 1878.6          | 1875                | 4                 | 18 2.16                            | +0.007 | —                                         | —                        |
| 34                     | Madras An. 54I               | 1879.31         | 1879                | 2                 | 18 14.24                           | +0.001 | —                                         | 12.068                   |
| 30                     | Ten-Year 1935                | 1883.24         | 1880                | 3                 | 18 17.234                          | .000   | —                                         | 15.084                   |
| Results                |                              | 1855.01         | 1875                | 121               | 12 18 2.182                        | -0.010 | —                                         | —                        |
| 1                      | Bradley 1661                 | 1754.2          | 1755                | 3                 | 26 87 35.1                         | .00    | -40                                       | 4.42                     |
| 4                      | d'Agelet 293I                | 1783.37         | 1800                | 2                 | 72 31.4                            | -0.35  | -25                                       | 2.14                     |
| 3                      | Lalande 232II                | 1794.31         | 1800                | 1                 | 72 32.5                            | -0.12  | -25                                       | 2.14                     |
| 2                      | Piazzi 70                    | 1801.28         | 1800                | 9                 | 72 34.0                            | +0.03  | -25                                       | 2.14                     |
| 5                      | Bessel (W <sub>1</sub> ) 35I | 1830.32         | 1825                | 2                 | 64 10.3                            | +0.11  | -16                                       | 41.18                    |
| 7                      | Pond 502                     | 1831.06         | 1830                | 14                | 62 33.3                            | +0.02  | -15                                       | 1.02                     |
| 8                      | Taylor 569I                  | [1831.5]        | 1835                | 6                 | 60 51.91                           | -0.07  | -13                                       | 20.86                    |
| 12                     | Paris, 15182                 | 1838.0          | 1845                | 4                 | 57 30.6                            | -0.15  | -10                                       | 0.59                     |
| 9                      | Rümker 3950                  | [1841]          | 1836                | 8                 | 60 32.28                           | +0.10  | -13                                       | 0.84                     |
| 16                     | Poulkova 1862                | 1841.34         | 1855                | 4                 | 54 11.00                           | .00    | -6                                        | 40.35                    |
| 32                     | Edinb. An.                   | 1842.30         | 1842                | 3                 | 58 32.4                            | +0.01  | -11                                       | 0.67                     |
| 15                     | Six-Year 802                 | 1849.3          | 1850                | 2                 | 55 51.48                           | .00    | -8                                        | 20.46                    |
| 10                     | Robinson 2665                | 1849.67         | 1840                | 5                 | 59 11.46                           | +0.20  | -11                                       | 40.73                    |
| 18                     | Seven-Year 977               | 1854.3          | 1860                | 6                 | 52 30.93                           | +0.05  | -5                                        | 0.25                     |
| 19                     | Paris, 15182                 | 1860.8          | 1860                | 2                 | 52 30.9                            | +0.02  | -5                                        | 0.25                     |
| 21                     | Bruxelles 5072               | 1862.77         | 1865                | 2                 | 50 51.47                           | -0.05  | -3                                        | 20.15                    |
| 27                     | Rogers 534                   | 1872.6          | 1875                | 12                | 47 30.91                           | -0.01  | —                                         | —                        |
| 28                     | Respighi 686                 | 1875.31         | 1875                | 20                | 47 30.23                           | .00    | —                                         | —                        |
| 34                     | Madras An. 468               | 1878.39         | 1878                | 3                 | 46 32.2                            | +0.01  | +1                                        | 0.04                     |
| 25                     | Romberg 2754                 | 1878.4          | 1875                | 4                 | 47 31.3                            | .00    | —                                         | —                        |
| 29                     | A. G. C. 6102                | 1878.6          | 1875                | 4                 | 47 30.3                            | +0.08  | —                                         | —                        |
| 34                     | Madras An. 54I               | 1879.31         | 1879                | 2                 | 46 12.0                            | .00    | +1                                        | 20.05                    |
| 30                     | Ten-Year 1935                | 1883.24         | 1880                | 3                 | 45 50.62                           | .00    | +1                                        | 40.06                    |
| Results                |                              | 1857.40         | 1875                | 121               | 26 47 30.73                        | +0.30  | —                                         | —                        |

$$J = + 3^{\circ}.01718$$

$$K = - 0.01156$$

$$P = + 0.014$$

$$L = - 20''.0132$$

$$M = + 0.0432$$

$$N = + 0.16$$

| Right Asc.<br>1875.<br>$\alpha$  | System-<br>atic Corr. | $a + A$<br>$B_a$           | Weight. | $\Delta\mu_0(t-T_0)$<br>$F_a$       | Corrected<br>R. A. 1875.<br>$B_a' = B_a + F_a$                | $a_0 - B_a'$<br>$V_a$                |
|----------------------------------|-----------------------|----------------------------|---------|-------------------------------------|---------------------------------------------------------------|--------------------------------------|
| Declination<br>1875.<br>$\delta$ | $A$                   | $\delta + A$<br>$B_\delta$ | $p$     | $\Delta\mu_0'(t-T_0)$<br>$F_\delta$ | Corrected<br>Decl. 1875.<br>$B_\delta' = B_\delta + F_\delta$ | $\delta_0 - B_\delta'$<br>$V_\delta$ |
| h m s                            | s                     | s                          |         | s                                   | s                                                             | s                                    |
| 12 18 2.268                      | 0.000                 | 2.268                      | 0.6     | -0.050                              | 2.218                                                         | -0.036                               |
| 18 1.737                         | +0.333                | 2.070                      | 0.2     | -0.036                              | 2.034                                                         | +0.148                               |
| 18 1.859                         | +0.254                | 2.113                      | 0.1     | -0.030                              | 2.083                                                         | +0.099                               |
| 18 1.803                         | +0.254                | 2.057                      | 0.3     | -0.027                              | 2.030                                                         | +0.152                               |
| 18 2.116                         | +0.156                | 2.272                      | 0.2     | -0.012                              | 2.260                                                         | -0.078                               |
| 18 2.384                         | -0.017                | 2.367                      | 0.6     | -0.012                              | 2.355                                                         | -0.173                               |
| 18 2.195                         | -0.057                | 2.138                      | 0.5     | -0.011                              | 2.127                                                         | +0.055                               |
| 18 2.104                         | +0.068                | 2.172                      | 0.5     | -0.009                              | 2.163                                                         | +0.019                               |
| 18 2.123                         | +0.047                | 2.170                      | 2.0     | -0.009                              | 2.161                                                         | +0.021                               |
| 18 2.144                         | -0.049                | 2.095                      | 1.0     | -0.007                              | 2.088                                                         | +0.094                               |
| 18 2.127                         | +0.039                | 2.166                      | 0.5     | -0.007                              | 2.159                                                         | +0.023                               |
| 18 2.187                         | +0.059                | 2.246                      | 2.0     | -0.007                              | 2.239                                                         | -0.057                               |
| 18 2.181                         | -0.012                | 2.169                      | 0.3     | -0.006                              | 2.163                                                         | +0.019                               |
| 18 2.264                         | -0.013                | 2.251                      | 1.0     | .000                                | 2.251                                                         | -0.069                               |
| 18 2.071                         | +0.051                | 2.122                      | 0.7     | +0.002                              | 2.124                                                         | +0.058                               |
| 18 2.142                         | +0.044                | 2.186                      | 1.0     | +0.003                              | 2.189                                                         | -0.007                               |
| 18 2.214                         | +0.006                | 2.220                      | 2.0     | +0.005                              | 2.225                                                         | -0.043                               |
| 18 2.182                         | +0.003                | 2.185                      | 3.0     | +0.009                              | 2.194                                                         | -0.012                               |
| 18 2.030                         | +0.018                | 2.048                      | 1.0     | +0.012                              | 2.060                                                         | +0.122                               |
| 18 2.160                         | -0.003                | 2.157                      | 2.0     | +0.012                              | 2.169                                                         | +0.013                               |
| 18 2.167                         | .000                  | 2.167                      | 1.0     | +0.012                              | 2.179                                                         | +0.003                               |
| 18 2.173                         | +0.018                | 2.191                      | 0.7     | +0.012                              | 2.203                                                         | -0.021                               |
| 18 2.150                         | +0.010                | 2.160                      | 1.0     | +0.014                              | 2.174                                                         | +0.008                               |
| 12 18 2.172                      | $\pm 0.0063$          | $\pm 0.0081$               | 22.2    | -0.0025                             | $\pm 0.0002$                                                  | 14971                                |
| 26 47 30.68                      | "0.00                 | 30.68                      | 0.4     | +1.75                               | 32.43                                                         | -1.70                                |
| 47 28.91                         | -1.38                 | 27.53                      | 0.2     | +1.26                               | 28.79                                                         | +1.94                                |
| 47 30.24                         | -2.60                 | 27.64                      | 0.1     | +1.07                               | 28.71                                                         | +2.02                                |
| 47 31.89                         | -2.60                 | 29.29                      | 0.3     | +0.95                               | 30.24                                                         | +0.49                                |
| 47 29.23                         | -0.22                 | 29.01                      | 0.2     | +0.46                               | 29.47                                                         | +1.26                                |
| 47 32.30                         | -1.90                 | 30.40                      | 1.0     | +0.45                               | 30.85                                                         | -0.12                                |
| 47 30.98                         | -0.80                 | 30.18                      | 0.5     | +0.44                               | 30.62                                                         | +0.11                                |
| 47 29.86                         | -0.45                 | 29.41                      | 1.0     | +0.33                               | 29.74                                                         | +0.99                                |
| 47 31.54                         | -0.30                 | 31.24                      | 0.5     | +0.28                               | 31.52                                                         | -0.79                                |
| 47 30.65                         | -0.02                 | 30.63                      | 2.0     | +0.27                               | 30.90                                                         | -0.17                                |
| 47 31.74                         | -1.12                 | 30.62                      | 0.3     | +0.26                               | 30.88                                                         | -0.15                                |
| 47 31.02                         | -0.20                 | 30.82                      | 0.7     | +0.14                               | 30.96                                                         | -0.23                                |
| 47 30.93                         | -0.82                 | 30.11                      | 0.5     | +0.13                               | 30.24                                                         | +0.49                                |
| 47 30.73                         | -0.09                 | 30.64                      | 2.0     | +0.05                               | 30.69                                                         | +0.04                                |
| 47 30.67                         | -0.28                 | 30.39                      | 0.7     | -0.06                               | 30.33                                                         | +0.40                                |
| 47 31.27                         | -0.02                 | 31.25                      | 0.7     | -0.09                               | 31.16                                                         | -0.43                                |
| 47 30.90                         | +0.26                 | 31.16                      | 3.0     | -0.26                               | 30.90                                                         | -0.17                                |
| 47 30.23                         | +0.40                 | 30.63                      | 1.5     | -0.30                               | 30.33                                                         | +0.40                                |
| 47 32.25                         | -0.29                 | 32.96                      | 1.0     | -0.36                               | 31.60                                                         | -0.87                                |
| 47 31.30                         | +0.01                 | 31.31                      | 2.0     | -0.36                               | 30.95                                                         | -0.22                                |
| 47 30.38                         | .00                   | 30.38                      | 1.0     | -0.36                               | 30.02                                                         | +0.71                                |
| 47 32.05                         | -0.29                 | 31.76                      | 0.7     | -0.37                               | 31.39                                                         | -0.66                                |
| 47 30.68                         | +0.08                 | 30.76                      | 1.0     | -0.44                               | 30.32                                                         | +0.41                                |
| 26 47 31.03                      | $\pm 0.087$           | $\pm 0.107$                | 21.3    | -0.004                              | $\pm 0.0035$                                                  | 13043                                |

## 12 B. D. 26°.2345—68 Comæ Berenices (20 CHASE).

$$\begin{array}{rclclcl} \alpha_{1875} & 12^h & 18^m & 10^s.24 & \mu, & 0^s.000 \\ \delta_{1875} & 26^\circ & 16' & 33''.3 & \mu', & 0''.00 \end{array}$$

| No. of Cat.<br>Sec. I. | Authority.               | Date of<br>Obs. | Epoch<br>of<br>Cat. | No.<br>of<br>Obs. | Right Asc.<br>at Epoch<br>of Cat.  | Corr. for<br>Errone's<br>Proper<br>Motion. | Reduction<br>to<br>1875. |
|------------------------|--------------------------|-----------------|---------------------|-------------------|------------------------------------|--------------------------------------------|--------------------------|
|                        |                          |                 |                     |                   | Declination<br>at Epoch<br>of Cat. |                                            |                          |
|                        |                          | t               | T                   | n                 | h m s                              | s                                          | m s                      |
| 4                      | d'Agelet 2933            | 1785.25         | 1800                | 1                 | 12 14 23.7                         | 0.000                                      | +3 46.820                |
| 3                      | Lalande 23214            | 1794.31         | 1800                | 2                 | 14 23.04                           | .000                                       | +3 46.820                |
| 6                      | Σ.Pos. Med. 1417         | 1828.5          | 1830                | 6                 | 15 54.38                           | .000                                       | +2 16.014                |
| 16                     | Poulkova 1863            | 1841.32         | 1855                | 4                 | 17 9.93                            | .000                                       | +1 0.422                 |
| 31                     | Camb. An.                | 1842.32         | 1842                | 3                 | 16 30.70                           | .000                                       | +1 39.720                |
| 19                     | Paris <sub>3</sub> 15186 | 1863.3          | 1860                | 1                 | 17 24.99                           | .000                                       | + 45.312                 |
| 21                     | Bruxelles 5073           | 1871.70         | 1865                | 3                 | 17 40.00                           | .000                                       | + 30.205                 |
| 24                     | Dreyer 1423              | 1873.30         | 1875                | 7                 | 18 10.24                           | .000                                       | —                        |
| 26                     | Paris <sub>3</sub> 15186 | 1874.3          | 1875                | 7                 | 18 10.27                           | .000                                       | —                        |
| 25                     | Romberg 2755             | 1875.3          | 1875                | 5                 | 18 10.23                           | .000                                       | —                        |
| 29                     | A. G. C. 6104            | 1876.4          | 1875                | 2                 | 18 10.24                           | .000                                       | —                        |
|                        | <b>Results</b>           | <b>1858.93</b>  | <b>1875</b>         | <b>41</b>         | <b>12 18 10.317</b>                | <b>—0.051</b>                              | <b>—</b>                 |
|                        |                          |                 |                     |                   | h m s                              | s                                          | m s                      |
| 4                      | d'Agelet 2933            | 1785.25         | 1800                | 1                 | 26 41 34.9                         | 0.00                                       | —25 0.50                 |
| 3                      | Lalande 23214            | 1794.31         | 1800                | 2                 | 41 35.4                            | .00                                        | —25 0.50                 |
| 6                      | Σ.Pos. Med. 1417         | 1828.5          | 1830                | 6                 | 31 32.8                            | .00                                        | —15 0.03                 |
| 16                     | Poulkova 1863            | 1841.32         | 1855                | 4                 | 23 13.2                            | .00                                        | — 6 39.91                |
| 31                     | Camb. An.                | 1842.33         | 1842                | 3                 | 27 33.82                           | .00                                        | —10 59.95                |
| 21                     | Bruxelles 5073           | 1870.78         | 1865                | 2                 | 19 53.00                           | .00                                        | — 3 19.94                |
| 26                     | Paris <sub>3</sub> 15186 | 1874.3          | 1875                | 7                 | 16 33.3                            | .00                                        | —                        |
| 25                     | Romberg 2755             | 1875.3          | 1875                | 5                 | 16 33.2                            | .00                                        | —                        |
| 24                     | Dreyer 1423              | 1876.12         | 1875                | 5                 | 16 32.7                            | .00                                        | —                        |
| 29                     | A. G. C. 6104            | 1876.4          | 1875                | 2                 | 16 33.3                            | .00                                        | —                        |
|                        | <b>Results</b>           | <b>1858.81</b>  | <b>1875</b>         | <b>37</b>         | <b>26 16 32.89</b>                 | <b>+0.26</b>                               | <b>—</b>                 |

$$J = + 3^{\circ}.01997$$

$$L = - 19''.9913$$

$$K = - 0.01125$$

$$M = + 0.0435$$

$$P = + 0.013$$

$$N = + 0.16$$

| Right Asc.<br>1875.<br>$\alpha$  | System-<br>atic Corr. | $a + A.$<br>$B_a$           | Weight. | $\Delta\mu_0(t-T_0)$<br>$F_a$        | Corrected<br>R. A. 1875.<br>$B_a' = B_a + F_a$                | $a_0 - B_a'$<br>$v_a$                |
|----------------------------------|-----------------------|-----------------------------|---------|--------------------------------------|---------------------------------------------------------------|--------------------------------------|
| Declination<br>1875.<br>$\delta$ | $\Lambda$             | $\delta + A.$<br>$B_\delta$ | $p$     | $\Delta\mu_0'(t-T_0).$<br>$F_\delta$ | Corrected<br>Decl. 1875.<br>$B_\delta' = B_\delta + F_\delta$ | $\delta_0 - B_\delta'$<br>$v_\delta$ |
| h m s                            | s                     | s                           |         | s                                    | s                                                             | s                                    |
| 12 18 10.520                     | +0.331                | 10.851                      | 0.1     | -0.236                               | 10.615                                                        | -0.298                               |
| 18 9.860                         | +0.252                | 10.112                      | 0.2     | -0.207                               | 9.905                                                         | +0.412                               |
| 18 10.394                        | +0.044                | 10.438                      | 2.0     | -0.097                               | 10.341                                                        | -0.024                               |
| 18 10.352                        | +0.059                | 10.411                      | 2.0     | -0.056                               | 10.355                                                        | -0.038                               |
| 18 10.420                        | -0.075                | 10.345                      | 1.0     | -0.053                               | 10.292                                                        | +0.025                               |
| 18 10.302                        | +0.051                | 10.353                      | 0.3     | +0.014                               | 10.367                                                        | -0.050                               |
| 18 10.205                        | +0.044                | 10.249                      | 1.0     | +0.041                               | 10.290                                                        | +0.027                               |
| 18 10.240                        | +0.041                | 10.281                      | 1.5     | +0.046                               | 10.327                                                        | -0.010                               |
| 18 10.270                        | +0.042                | 10.312                      | 2.0     | +0.049                               | 10.361                                                        | -0.044                               |
| 18 10.230                        | -0.003                | 10.227                      | 3.0     | +0.052                               | 10.279                                                        | +0.038                               |
| 18 10.240                        | .000                  | 10.240                      | 1.0     | +0.056                               | 10.296                                                        | +0.021                               |
| 12 18 10.266                     | $\pm 0.0080$          | $\pm 0.0101$                | 14.1    | -0.0032                              | $\pm 0.0004$                                                  | 6186                                 |
| 26 16 34.40                      | -1.42                 | 32.98                       | 0.1     | +1.18                                | 34.16                                                         | -1.27                                |
| 16 34.90                         | -2.64                 | 32.26                       | 0.2     | +1.03                                | 33.29                                                         | -0.40                                |
| 16 32.77                         | -1.04                 | 31.73                       | 2.0     | +0.48                                | 32.21                                                         | +0.68                                |
| 16 33.29                         | -0.02                 | 33.27                       | 2.0     | +0.28                                | 33.55                                                         | -0.66                                |
| 16 33.87                         | -1.28                 | 32.59                       | 1.0     | +0.26                                | 32.85                                                         | +0.04                                |
| 16 33.06                         | -0.02                 | 33.04                       | 0.7     | -0.19                                | 32.85                                                         | +0.04                                |
| 16 33.30                         | -0.22                 | 33.08                       | 2.0     | -0.25                                | 32.83                                                         | +0.06                                |
| 16 33.20                         | -0.01                 | 33.19                       | 3.0     | -0.26                                | 32.93                                                         | -0.04                                |
| 16 32.70                         | -0.27                 | 32.97                       | 1.5     | -0.28                                | 32.69                                                         | +0.20                                |
| 16 33.30                         | .00                   | 33.30                       | 1.0     | -0.28                                | 33.02                                                         | -0.13                                |
| 26 16 33.15                      | $\pm 0.109$           | $\pm 0.137$                 | 13.5    | +0.016                               | $\pm 0.0051$                                                  | 6249                                 |



A few observations of other stars were found. I have recorded them here for the sake of completeness. They were not reduced, however, as the resulting positions and proper motions would be entitled to but little confidence, and would be of no value whatever for my purpose.

## ADDITIONAL STARS.

| No.<br>in<br>Sec. I.           | Authority.                    | Epoch. | Right Asc.<br>at Epoch<br>of Cat. | Date.   | No.<br>of<br>Obs. | Declination<br>at Epoch<br>of Cat. | Date.   | No.<br>of<br>Obs. |
|--------------------------------|-------------------------------|--------|-----------------------------------|---------|-------------------|------------------------------------|---------|-------------------|
| (13) B. D. 26°.2330.           |                               |        |                                   |         |                   |                                    |         |                   |
| 5                              | Bessel (W <sub>1</sub> .) 284 | 1825   | <sup>h m s</sup><br>12 11 56.00   | 1831.31 | 1                 | 26° 44' 15.5                       | 1831.31 | 1                 |
| 26                             | Paris <sub>3</sub> 15108      | 1875   | 14 27.83                          | 1873.4  | 1                 | 27 (36)                            | —       | —                 |
| 29                             | A. G. C. 6074                 | 1875   | 14 27.92                          | 1876.9  | 2                 | 27 35.8                            | 1876.9  | 2                 |
| (14) B. D. 26°.2331 (8 CHASE). |                               |        |                                   |         |                   |                                    |         |                   |
| 5                              | Bessel (W <sub>1</sub> .) 288 | 1825   | <sup>h m s</sup><br>12 12 4.38    | 1831.31 | 1                 | 26° 53' 51.2                       | 1831.31 | 1                 |
| 29                             | A. G. C. 6077                 | 1875   | 14 35.55                          | 1877.3  | 3                 | 37 13.6                            | 1877.3  | 3                 |
| (15) B. D. 26°.2347.           |                               |        |                                   |         |                   |                                    |         |                   |
| 21                             | Bruxelles 5075                | 1865   | <sup>h m s</sup><br>12 18 15.72   | 1869.37 | 2                 | 26° 18' 32.74                      | 1871.63 | 3                 |
| 29                             | A. G. C. 6105                 | 1875   | 18 46.06                          | 1878.0  | 6                 | 15 13.1                            | 1878.0  | 6                 |

The above table is not intended to be exhaustive ; it includes only such stars as were found in more than one catalogue. A number of stars, the positions of which are given in the *Astronomische Gesellschaft Catalog*, and which fall within the limits of my zone, are not mentioned here for the reason stated.

**Catalogue of Results.**—For convenience, I have collected into a table the final positions and proper motions deduced from the data given on the foregoing pages. The quantities in this table all refer to the epoch 1875 ; the corresponding quantities for the date of observation  $T_0$ , will be found in the *Star Tables* under the heading “Results.” The columns in the “Catalogue” require but little explanation. They are as

follows : Col. 1 shows the Name or the B. A. C. or B. D. number of the star ; 2 and 3 the Right Ascension and Probable Error in Right Ascension for 1875, respectively ; 4 and 5 the *geometric* Precession and Secular Variation respectively ; 6 and 7 the Proper Motion in Right Ascension and its Probable Error ; 8 the mean Date of Observation,  $T_0$  ; and 9 the Number of Observations from which the results were obtained. Columns 10 to 17 have the same significance as 2 to 9, but refer to the declination. Column 18 contains Chase's number, and 19 the number assigned by me to the star in question. It should be mentioned, that the declination of B.A.C. 4153 as here given does not include Respighi's observations of that star, which were accidentally overlooked, as the omission was not discovered until all the succeeding calculations had been made. The error introduced thereby is so trifling, however—being only  $0''.03$  in the position and  $0''.001$  in the proper motion—that I have not deemed it necessary to carry through the correction. The constants of the plates, to compute which these positions are used, would not be changed by doing so. I have, therefore, left the quantities as they were used in the succeeding part of the work, although, of course, the corrected position including Respighi's observations would otherwise have been preferable.

## Catalogue of Twelve Stars of the Cluster in

Mean equinox of 1875.0.

| Name.          | Right Asc.<br>at 1875.                 | Prob. Err.<br>of<br>R. A. | Precess.<br>+ | Sec. Var.<br>— | Prop.<br>Mot. in<br>R. A. | Prob. Err.<br>of Prop.<br>Mot. | Date<br>of<br>Obs. | No.<br>of<br>Obs. |
|----------------|----------------------------------------|---------------------------|---------------|----------------|---------------------------|--------------------------------|--------------------|-------------------|
|                | <sup>h</sup> <sup>m</sup> <sup>s</sup> | <sup>s</sup>              | <sup>s</sup>  | <sup>s</sup>   | <sup>s</sup>              | <sup>s</sup>                   |                    |                   |
| B. D. 26°.2324 | 12 12 22.900                           | ±0.0146                   | 3.0356        | 0.0122         | —0.0026                   | ±0.0010                        | 1873.63            | 15                |
| 43 Comæ B.     | 12 43.731                              | ±0.0136                   | 3.0349        | 0.0120         | —0.0019                   | ±0.0005                        | 1863.01            | 29                |
| 51 Comæ B.     | 14 1.113                               | ±0.0134                   | 3.0312        | 0.0119         | —0.0140                   | ±0.0005                        | 1864.89            | 38                |
| B. A. C. 4153  | 14 2.520                               | ±0.0125                   | 3.0300        | 0.0122         | —0.0071                   | ±0.0006                        | 1860.30            | 48                |
| B. D. 26°.2332 | 14 47.387                              | ±0.0273                   | 3.0294        | 0.0116         | —0.0016                   | ±0.0011                        | 1861.01            | 9                 |
| B. D. 25°.2493 | 14 47.581                              | ±0.0174                   | 3.0307        | 0.0112         | —0.0166                   | ±0.0008                        | 1865.34            | 16                |
| B. D. 25°.2495 | 15 9.118                               | ±0.0196                   | 3.0298        | 0.0112         | —0.0032                   | ±0.0008                        | 1859.70            | 12                |
| 12 e. Comæ B.  | 16 13.202                              | ±0.0062                   | 3.0250        | 0.0116         | —0.0022                   | ±0.0002                        | 1859.97            | 161               |
| B. D. 26°.2338 | 16 14.293                              | ±0.0146                   | 3 0250        | 0.0116         | +0.0004                   | ±0.0032                        | 1875.12            | 11                |
| B. A. C. 4178  | 17 46.945                              | ±0.0109                   | 3.0205        | 0.0114         | —0.0020                   | ±0.0005                        | 1865.15            | 42                |
| 13 f. Comæ B.  | 18 2.172                               | ±0.0081                   | 3.0192        | 0.0116         | —0.0025                   | ±0.0002                        | 1855.01            | 121               |
| 68 Comæ B.     | 18 10.266                              | ±0.0101                   | 3 0200        | 0.0112         | —0.0032                   | ±0.0004                        | 1858.93            | 41                |

## Coma Berenices from Meridian Observations.

Epoch 1875.0.

| Declination<br>at 1875. | Prob. Err.<br>of<br>Declin. | Precess.<br>— | Sec.<br>Var.<br>+ | Prop.<br>Mot. in<br>Decl. | Prob. Err.<br>of Prop.<br>Mot. | Date<br>of<br>Obs. | No.<br>of<br>Obs. | Chase's<br>No. | Kretz's<br>No. |
|-------------------------|-----------------------------|---------------|-------------------|---------------------------|--------------------------------|--------------------|-------------------|----------------|----------------|
| 26° 52' 58.21           | ±0.196                      | 20.025        | 0.032             | +0.086                    | ±0.0135                        | 1873.63            | 15                | 2              | 1              |
| 26 42 10.65             | ±0.173                      | 20.023        | 0.033             | —0.009                    | ±0.0069                        | 1863.17            | 37                | 3              | 2              |
| 26 41 42.94             | ±0.171                      | 20.017        | 0.036             | +0.030                    | ±0.0069                        | 1864.06            | 37                | 5              | 4              |
| 27 19 2.26              | ±0.136                      | 20.017        | 0.036             | —0.106                    | ±0.0075                        | 1863.38            | 83                | 6              | 5              |
| 26 21 53.14             | ±0.317                      | 20.012        | 0.037             | —0.078                    | ±0.0146                        | 1866.30            | 9                 | 9              | 8              |
| 25 43 14.48             | ±0.205                      | 20.012        | 0.037             | +0.144                    | ±0.0120                        | 1869.33            | 15                | 10             | 9              |
| 25 41 28.01             | ±0.262                      | 20.010        | 0.038             | +0.004                    | ±0.0100                        | 1856.23            | 15                | 11             | 10             |
| 26 32 23.98             | ±0.074                      | 20.004        | 0.040             | +0.007                    | ±0.0028                        | 1865.03            | 171               | d              | 14             |
| 26 31 20.26             | ±0.209                      | 20.004        | 0.040             | +0.088                    | ±0.0300                        | 1874.43            | 11                | 14             | 15             |
| 26 32 40.72             | ±0.138                      | 19.994        | 0.043             | +0.015                    | ±0.0075                        | 1867.72            | 49                | 18             | 21             |
| 26 47 31.03             | ±0.107                      | 19.992        | 0.043             | —0.004                    | ±0.0035                        | 1857.40            | 121               | 19             | 22             |
| 26 16 33.15             | ±0.137                      | 19.991        | 0.044             | +0.016                    | ±0.0051                        | 1858.81            | 37                | 20             | 23             |

## PART II.

### MEASUREMENT AND REDUCTION OF THE PLATES.

#### I. The Plates: Description and Measurement.

**Description.**—The photographs of Coma Berenices were taken with Rutherford's large telescope in the years 1870, 1875 and 1876. They differ in no particular from his other star plates. There are always two images of each star, obtained by stopping the driving clock a few seconds after the first exposure had been made, and then starting it again, leaving, meanwhile, the plate in position so that another impression could be made. A third image (or "trail") of the brightest stars is usually found at the distance of about 35 mm. from the second image, obtained in a similar manner, except that the clock was stopped for a longer time than in the previous case. These trails were intended to give an independent means of orienting the plate. I have not used them otherwise than to place the photograph correctly in the measuring machine; for Dr. Schlesinger<sup>1</sup> has shown that no reliance can be placed on the trails for other purposes.

The plates are by no means uniform in quality, some of them giving a much sharper picture than others. Especially noticeable, and at the same time rather annoying, is the elongation of the images on some of the photographs due to irregularities in the clock, which failed to keep pace exactly with the diurnal mo-

<sup>1</sup> "The Præsepe Group, Measurement and Reduction of the Rutherford Photographs" by Frank Schlesinger. *Annals of the N. Y. Academy of Sciences*, Vol. X. The page referred to is 282.

tion of the stars. Then, again, the number of stars visible on the different plates varies greatly. This is the case even when the exposures were taken on the same night, although these were always of the same length, namely six minutes. The largest number of stars is found on the plates taken in 1875. In spite of their variable quality, however, I decided not to omit any of them, but to measure on each one all the stars that could be plainly seen. This was necessitated by the fact that I had but three plates of the early date; and again but five taken in 1875 and showing a fairly large number of stars. None of these could well be rejected without seriously injuring either the proper motions in the one case, or the positions in the other. But thereby the standard of excellence was placed so low, that none of the others could legitimately be omitted. The result is, that some of the stars show quite large residuals, due to the difficulty of measuring hazy images. Especially is this the case for stars just on the limits of visibility, and for those lying near the edge of the plate, where radial distortion becomes very marked. On the whole, the cluster is not well adapted to photographic measurement, as it is very scattered, and the range of brightness is large.

The origin of coördinates was taken to coincide with star 14 (12e Comæ Berenices). For the reduction it is necessary that the point be known approximately where a line from the optical center of the lens strikes the plate perpendicularly. Rutherford always so adjusted his instrument, that this line should pass through the image of some bright star, no. 14, in my case.

I subjoin TABLE I, giving all necessary data regarding the plates. The column "Date" shows the date, and that headed "Sidereal Time," the time of exposure. This latter is the mean of four instants, namely the beginning and end of the first, and the beginning and end of the second exposure. Next follow the reading of the barometer, together with the attached and external thermometers. The 7th and 8th columns refer to the telescope, the former showing the readings of a thermometer in contact with the tube, and the latter the reading of a micrometer head at the eye end. This latter quantity depends



on the distance of the plateholder from the object glass, and may bear some relation to the scale value; a question which cannot be settled, however, until many more of the Rutherford photographs have been independently reduced. In the last column will be found remarks regarding the quality of the plate, and the number of stars measured.

TABLE I.—THE PLATES.

Observatory of Lewis M. Rutherford, New York City.

Lat. =  $40^{\circ} 43' 48''.5$

Long. =  $4^h 55^m 56^s.62$  W.

| No.  | Exposures.      |            | Atmosphere. |            |            | Telescope. |        | Remarks.            |
|------|-----------------|------------|-------------|------------|------------|------------|--------|---------------------|
|      | Date.           | Sid. Time. | Bar.        | Att. Ther. | Ext. Ther. | Ther.      | Focus. |                     |
|      |                 | h m s      |             | °          | °          | °          |        |                     |
| I    | 1870. April 25. | 13 24 08   | 30.260      | 53         | 47         | 53         | 8.4    | Good ; 13 stars.    |
| II   | 1870. April 25  | 14 00 05   | 30.260      | 53         | 47         | 53         | 8.4    | Fair ; 17 stars.    |
| III  | 1870. April 26. | 12 20 55   | 30.200      | 58         | 53         | 58         | 8.5    | Good ; 15 stars.    |
| IV   | 1875. June 2.   | 14 16 18   | 30.250      | 60         | 56         | 60         | 7.7    | Good ; 20 stars.    |
| V    | 1875. June 2    | 14 47 02   | 30.250      | 60         | 56         | 60         | 7.7    | Good ; 18 stars.    |
| VI   | 1875. June 2.   | 15 16 32   | 30.250      | 60         | 56         | 60         | 7.7    | Good ; 22 stars.    |
| VII  | 1875. June 4.   | 14 43 12   | 30.250      | 68         | 66         | 70         | 7.6    | Poor ; 16 stars.    |
| VIII | 1875. June 4.   | 15 13 02   | 30.250      | 68         | 66         | 70         | 7.6    | Good ; 23 stars.    |
| IX   | 1876. May 26.   | 13 27 18   | 30.136      | 59         | 55         | 60         | 7.7    | V. Good ; 14 stars. |
| X    | 1876. May 26.   | 13 55 38   | 30.136      | 59         | 55         | 60         | 7.7    | Good ; 16 stars.    |
| XI   | 1876. May 26.   | 14 24 52   | 30.136      | 59         | 55         | 60         | 7.7    | Good ; 16 stars.    |
| XII  | 1876. May 26.   | 14 53 32   | 30.136      | 59         | 55         | 60         | 7.7    | Fair ; 16 stars.    |
| XIII | 1876. May 27.   | 13 20 38   | 30.086      | 66         | 63         | 65         | 7.65   | Poor : 15 stars.    |
| XIV  | 1876. May 27.   | 13 51 52   | 30.086      | 66         | 63         | 65         | 7.65   | Fair ; 16 stars.    |

**Measurement.**—The fourteen plates were measured during the winters 1896–1897 and 1897–1898, and one of them in the fall of 1898. During the first year, three observers were engaged in the work: Mr. William H. Hays, then graduate student in astronomy, Dr. Schlesinger, and myself; after the spring of 1897 only the latter two remained. In this connection, I wish to thank the two gentlemen, Messrs. Hays and Schlesinger, for their interested and arduous services rendered in my behalf.

The older Repsold measuring machine of the observatory was used throughout. A full description of one of these ex-

cellent instruments will be found in Dr. Scheiner's recent work "Die Photographie der Gestirne," p. 148. I shall say only a few words on the subject: The essential features of the machine are a strong iron frame, to which are attached a circular movable plate-holder, and two parallel fixed bridges, one bearing three microscopes and the other a straight scale. The holder is capable of rotation about its centre, and of motion in a direction perpendicular to the bridges. In this motion it is guided by an accurately straight steel cylinder, which is long enough to permit the entire plate to pass underneath the microscope bridge. This latter bears, as already stated, three microscopes. Two of them are permanently fixed to either end, and point at a graduated circle on the circumference of the holder. They contain comb-micrometers, and read to seconds of arc. The third, or measuring microscope, is mounted on a straight guiding-way, and has motion entirely across the plate, in a direction perpendicular to the cylinder. It is evident that any point on the plate may be brought into the field of view. At the left hand end of the bridge is attached a lever arm, by means of which the guiding-way together with the microscope may be raised through a small angle. When in this position, the microscope points at the scale. Readings are made by means of a filar micrometer. This is so arranged, that two revolutions of the screw carry the wires over one division of the scale, *i. e.*, over one millimeter. The head is divided into one hundred parts, so that twothousandths of a millimeter can be read by estimation. As the machine was originally designed for the measurement of réseau plates, the microscope has two screws at right angles to each other; they are designated as the horizontal and the vertical screw respectively.

From the above description of the machine, the method of measuring follows immediately. The microscope being pointed at a star, the micrometer is read; then by means of the lever arm, it is made to point at the scale, and, without moving the microscope itself, the screw is turned until the threads cover the next lower division, and the head is again read. The difference of the two readings, *added* to the number of the line,

will give the position of the star with respect to the scale, since the micrometer is so arranged, that the head will show increasing numbers, when the threads are made to move in a direction opposite to increasing numbers on the scale. To measure the plate, then, the following operations were always performed :

Set the plate correctly in the holder, *i. e.*, so, that the measured coördinates will coincide approximately with right ascension and with declination. This is done by first making the line joining the central star with its trail (or third image) parallel to the cylinder, and then turning the plate through  $90^\circ$ , in such a way that the trail shall be *to the right*.<sup>1</sup> Then will the hour angle increase toward the left on the plate, and the direction of a circle of declination will be perpendicular to the scale. Read the graduated circle on both microscopes, observe for runs,<sup>2</sup> and take the temperature. Now measure the position of each star as follows: Point the microscope on the East Image of the star and read the micrometer ; point at the scale and read twice on the next lower line ; point again on the star and read. Move the microscope so that, the micrometer standing approximately at the same point as before, the wires bisect the West Image. Re-

<sup>1</sup> NOTE.—It will be seen that this method of orientation involves an error due to the curvature of the path of the central star on the plate, which, for high declinations, becomes large. For a star which describes a small circle in the sky will trace an arc on the photograph, and if the plate is oriented by the method described above, the cylinder will be made parallel to a tangent to this curve at the *middle point* between the central star and its trail, and not, as should be the case, at the star itself. It is easily seen that the value of this error in seconds of arc,  $x''$ , is

$$x'' = \frac{1}{2} d'' \tan \delta$$

where  $d''$  is the distance in seconds between the central star and its trail (obtained by multiplying the distance in mm. by an approximate scale value) and  $\delta$  is the declination of that star. If then we move the holder through an angle  $x''$ , the plate will be much more accurately oriented and the least square solution for the constants of reduction will be greatly simplified. The sign of this correction will depend on the position of the plate (whether in the northern or in the southern hemisphere), and also on the graduation of the plate-holder. In general it can be determined from the consideration that the true East and West line passes through a point which has an arithmetically smaller declination than the trail. In orienting my plates, I always applied the above correction. The method is due to Dr. Schlesinger.

<sup>2</sup> See Sect. II, "RUNS AND SCREW ERRORS."

peat the operation as for the East Image. Take the mean of the readings on the scale, and subtract from it the mean of the readings on both images. The difference, *divided by 2*, is the distance in millimeters of the *mean* position of the star beyond the given line on the scale. It is designated in the following by  $\frac{1}{2} m$ . Measure in this way all the stars, beginning with the central. Read the temperature. Remeasure all the stars in the inverse order, with the micrometer head set now at half a revolution from its previous position, in order to eliminate periodic errors of the screw. Read the runs, circles, and temperature.

In this way, on one day, all the stars were measured in one position of the plate. Two observers were always engaged on the work, each one reading all the stars, the runs, and the circles. After completing the measures in one position, the plate is rotated through  $90^\circ$ , and the process is repeated. It is then evident, that if the first position gave differences in right ascension, the second would give differences in declination. Since the two images are separated on the plate by about a millimeter in right ascension, it was in general necessary to use two lines on the scale when measuring that coördinate, while for the other only one was required. In all other respects the measures in both positions are entirely similar. To reduce personalty, observations were made with the plate respectively  $180^\circ$  and  $270^\circ$  from its original position, care being taken that the same pair of observers should always read one coördinate in both directions. The greater part of the systematic error, due to the difficulty of judging the center in hazy images, cannot be eliminated by this method, however. The only way to obviate its effect, is to multiply the number of the plates, if that is possible.

In TABLES II and III are recorded all the observational data from which the succeeding reductions are made. TABLE II gives the daily record: It shows the date of measuring the plate, the runs in millimeters on 10 mm. spaces, the circle readings, the mean temperature of the morning, the position of the plate, and the initials of the observers, Schlesinger, Hays or Kretz. The runs as here given are the mean of the two

observations taken before and after measuring the stars. The circle readings as recorded show the degrees and minutes of the right hand microscope, while the seconds are the mean of all the readings for the morning. The terms in the fifth column require a little explanation: It has been stated that the normal position for the plate is *trail right*. Measures taken in this position are designated as *x direct*. Counter-clockwise rotation of the holder, which is the direction of increasing numbers on the circle, brings the trails up. Measures in this position are denoted as *y direct*. The meaning of the other terms follows at once. It should be mentioned, that for trail right, right ascension, and for trail up, north polar distance, increase towards the left on the plate, and that the numbers on the scale increase towards the right.

TABLE III gives the uncorrected measured coördinates in terms of the scale-divisions and of  $\frac{1}{2} m$ , obtained as previously explained. As has been stated, the micrometer could be read by estimation to twothousandths of a millimeter. The mean being taken to one decimal further, unity in the last place of  $\frac{1}{2} m$  will be a tenth of a micron. This corresponds approximately to  $0''.005$ . The same statement applies to the quantities given in the fifth and ninth columns of the tables. In general it will be found that two lines are given for the *x*'s and one for the *y*'s, agreeing with what has previously been said on this subject. In a few cases a negative sign is attached to  $\frac{1}{2} m$ : this means that the next higher line on the scale was used. The numbers of the stars in the tables were assigned by me, and increase with the right ascension.

TABLE II.—DAILY RECORDS.

| Date,<br>1897. | Runs<br>in min. | Circle.                     | Ther. | Position of Plate. | Obs. |
|----------------|-----------------|-----------------------------|-------|--------------------|------|
| Plate V.       |                 |                             |       |                    |      |
| Jan. 29        | —0.0028         | 181° 28' 56 $\frac{3}{4}$ " | 64.6  | <i>y</i> direct.   | K, S |
| " 30           | —0.0030         | 91 29 2 $\frac{1}{2}$ "     | 64.6  | <i>x</i> direct.   | S, H |
| Feb. 1         | —0.0020         | 1 28 56 $\frac{1}{2}$ "     | 68.5  | <i>y</i> reversed. | K, S |
| " 2            | —0.0010         | 271 28 58 $\frac{1}{2}$ "   | 58.9  | <i>x</i> reversed. | S, H |
| Plate I.       |                 |                             |       |                    |      |
| Feb. 20        | —0.0028         | 5° 50' 0 $\frac{3}{4}$ "    | 65.2  | <i>x</i> direct.   | S, H |
| " 23           | +0.0060         | 95 49 59 $\frac{3}{4}$ "    | 65.0  | <i>y</i> direct.   | K, H |
| " 24           | +0.0018         | 275 49 59                   | 64.6  | <i>y</i> reversed. | K, H |
| " 25           | +0.0055         | 185 50 0 $\frac{1}{2}$ "    | 63.4  | <i>x</i> reversed. | S, H |
| Plate VI.      |                 |                             |       |                    |      |
| March 9        | +0.0065         | 271° 25' 7 $\frac{3}{4}$ "  | 62.7  | <i>x</i> direct.   | K, H |
| " 10           | +0.0065         | 91 25 8                     | 63.6  | <i>x</i> reversed. | K, H |
| " 11           | +0.0070         | 1 25 10 $\frac{3}{4}$ "     | 62.1  | <i>y</i> direct.   | S, H |
| " 12           | +0.0015         | 181 25 9 $\frac{3}{4}$ "    | 62.1  | <i>y</i> reversed. | S, H |
| Plate IV.      |                 |                             |       |                    |      |
| April 17       | +0.0168         | 91° 42' 40 $\frac{1}{4}$ "  | 65.7  | <i>x</i> direct.   | S, H |
| " 19           | +0.0152         | 181 42 40 $\frac{1}{2}$ "   | 64.8  | <i>y</i> direct.   | K, S |
| " 20           | +0.0170         | 1 42 38 $\frac{3}{4}$ "     | 68.1  | <i>y</i> reversed. | K, S |
| " 21           | +0.0140         | 271 42 41                   | 64.8  | <i>x</i> reversed. | S, H |
| Plate VII.     |                 |                             |       |                    |      |
| May 10         | +0.0340         | 181° 22' 19 $\frac{1}{4}$ " | 71.1  | <i>y</i> direct.   | K, S |
| " 11           | +0.0340         | 91 22 21 $\frac{1}{4}$ "    | 72.5  | <i>x</i> direct.   | K, S |
| " 12           | +0.0312         | 1 22 20 $\frac{3}{4}$ "     | 72.5  | <i>y</i> reversed. | K, S |
| " 18           | +0.0325         | 271 22 18 $\frac{3}{4}$ "   | 72.5  | <i>x</i> reversed. | K, S |
| Plate IX.      |                 |                             |       |                    |      |
| Dec. 3         | —0.0125         | 87° 01' 4 $\frac{3}{4}$ "   | 66.9  | <i>x</i> direct.   | K, S |
| " 4            | —0.0110         | 177 01 4 $\frac{1}{2}$ "    | 64.7  | <i>y</i> direct.   | K, S |
| " 7            | —0.0128         | 267 01 5 $\frac{1}{2}$ "    | 66.7  | <i>x</i> reversed. | K, S |
| " 8            | —0.0115         | 357 01 8 $\frac{1}{4}$ "    | 67.0  | <i>y</i> reversed. | K, S |
| Plate X.       |                 |                             |       |                    |      |
| Dec. 11        | —0.0125         | 266° 57' 27 $\frac{1}{2}$ " | 69.1  | <i>x</i> direct.   | K, S |
| " 14           | —0.0138         | 86 57 30 $\frac{1}{4}$ "    | 64.2  | <i>x</i> reversed. | K, S |
| " 16           | —0.0128         | 356 57 28 $\frac{3}{4}$ "   | 66.4  | <i>y</i> direct.   | K, S |
| " 18           | —0.0145         | 176 57 29 $\frac{3}{4}$ "   | 65.7  | <i>y</i> reversed. | K, S |



TABLE II.—(Continued.)

| Date,<br>1897-98. | Runs<br>in mm. | Circle                      | Ther. | Position of Plate. | Obs. |
|-------------------|----------------|-----------------------------|-------|--------------------|------|
| Plate VIII.       |                |                             |       |                    |      |
| Dec. 20.          | —0.0112        | 271° 21' 26 $\frac{1}{4}$ " | 63.5  | <i>x</i> direct.   | K, S |
| " 21.             | —0.0122        | 1 21 27 $\frac{1}{2}$ "     | 65.6  | <i>y</i> direct.   | K, S |
| " 23.             | —0.0138        | 91 21 25                    | 65.2  | <i>x</i> reversed. | K, S |
| " 24.             | —0.0142        | 181 21 26                   | 61.2  | <i>y</i> reversed. | K, S |
| Plate III.        |                |                             |       |                    |      |
| Jan. 4            | —0.0110        | 273° 28' 26 $\frac{3}{4}$ " | 66.2  | <i>x</i> direct.   | K, S |
| " 5               | —0.0110        | 3 28 24                     | 66.3  | <i>y</i> direct.   | K, S |
| " 6               | —0.0115        | 93 28 22 $\frac{3}{4}$ "    | 65.4  | <i>x</i> reversed. | K, S |
| " 11              | —0.0115        | 183 28 23                   | 66.3  | <i>y</i> reversed. | K, S |
| Plate XI.         |                |                             |       |                    |      |
| Jan. 22           | —0.0115        | 267° 23' 45 $\frac{1}{2}$ " | 67.8  | <i>y</i> reversed. | K, S |
| " 25              | —0.0110        | 177 23 42 $\frac{3}{4}$ "   | 65.8  | <i>x</i> reversed. | K, S |
| " 27              | —0.0110        | 87 23 40 $\frac{3}{4}$ "    | 65.8  | <i>y</i> direct.   | K, S |
| " 29              | —0.0118        | 357 23 44 $\frac{1}{4}$ "   | 65.5  | <i>x</i> direct.   | K, S |
| Plate XII.        |                |                             |       |                    |      |
| Feb. 1            | —0.0125        | 357° 17' 10 $\frac{1}{2}$ " | 59.1  | <i>x</i> direct.   | K, S |
| " 2               | —0.0135        | 87 17 7 $\frac{3}{4}$ "     | 59.0  | <i>y</i> direct.   | K, S |
| " 3               | —0.0105        | 177 17 7 $\frac{1}{2}$ "    | 59.3  | <i>x</i> reversed. | K, S |
| " 4               | —0.0120        | 267 17 7 $\frac{3}{4}$ "    | 59.6  | <i>y</i> reversed. | K, S |
| Plate XIII.       |                |                             |       |                    |      |
| Feb. 5            | —0.0112        | 357° 34' 15 $\frac{3}{4}$ " | 66.6  | <i>x</i> direct.   | K, S |
| " 8               | —0.0115        | 87 34 14 $\frac{1}{4}$ "    | 66.7  | <i>y</i> direct.   | K, S |
| " 9               | —0.0102        | 177 34 16 $\frac{1}{4}$ "   | 67.9  | <i>x</i> reversed. | K, S |
| " 11              | —0.0108        | 267 34 17 $\frac{1}{4}$ "   | 67.4  | <i>y</i> reversed. | K, S |
| Plate XIV.        |                |                             |       |                    |      |
| Feb. 16           | —0.0115        | 267° 52' 37 $\frac{1}{4}$ " | 61.4  | <i>x</i> direct.   | K, S |
| " 17              | —0.0088        | 87 52 36 $\frac{1}{4}$ "    | 59.5  | <i>y</i> reversed. | K, S |
| " 19              | —0.0118        | 357 52 38                   | 65.3  | <i>y</i> direct.   | K, S |
| " 22              | —0.0112        | 177 52 35 $\frac{1}{4}$ "   | 66.0  | <i>y</i> reversed. | K, S |
| Plate II.         |                |                             |       |                    |      |
| Oct. 28           | +0.0030        | 185° 57' 42 $\frac{3}{4}$ " | 70.4  | <i>x</i> direct.   | K, S |
| Nov. 1            | +0.0035        | 275 57 43                   | 69.6  | <i>y</i> direct.   | K, S |
| " 2               | —0.0008        | 5 57 41 $\frac{1}{2}$ "     | 67.3  | <i>x</i> reversed. | K, S |
| " 3               | —0.0018        | 95 57 43                    | 67.8  | <i>y</i> reversed. | K, S |

TABLE III: MEASUREMENTS.—PLATE I.

| Star.         | Lines. | $\frac{1}{2} m.$ |        | $S-H$   | Lines.        | $\frac{1}{2} m.$ |        | $K-H$   |  |
|---------------|--------|------------------|--------|---------|---------------|------------------|--------|---------|--|
|               |        | Schles.          | Hays.  |         |               | Kretz.           | Hays.  |         |  |
| $x$ direct.   |        |                  |        |         | $y$ direct.   |                  |        |         |  |
| 4             | 94.95  | 0.8579           | 0.8598 | —0.0019 | 73            | 0.9498           | 0.9482 | +0.0016 |  |
| 5             | 94.95  | 0.3450           | 0.3432 | + 18    | 116           | 0.3085           | 0.3049 | + 36    |  |
| 6             | 88.89  | 0.1529           | 0.1504 | + 25    | 57            | 0.9234           | 0.9231 | + 3     |  |
| 7             | 86.87  | 0.1874           | 0.1838 | + 36    | 68            | 0.8505           | 0.8469 | + 36    |  |
| 8             | 83.84  | 0.2339           | 0.2298 | + 41    | 54            | 0.8404           | 0.8398 | + 6     |  |
| 9             | 83.84  | 0.2649           | 0.2621 | + 28    | 7             | 0.5781           | 0.5762 | + 19    |  |
| 10            | 77.78  | 0.8001           | 0.8021 | — 20    | 5             | 0.5728           | 0.5715 | + 13    |  |
| 14            | 61.62  | 0.4092           | 0.4072 | + 20    | 63            | 0.3152           | 0.3158 | — 6     |  |
| 15            | 61.62  | 0.1330           | 0.1326 | + 4     | 62            | 0.1146           | 0.1151 | — 5     |  |
| 21            | 37.38  | 0.6348           | 0.6360 | — 12    | 63            | 0.6746           | 0.6749 | — 3     |  |
| 22            | 33.34  | 0.8319           | 0.8341 | — 22    | 80            | 0.5181           | 0.5142 | + 39    |  |
| 23            | 31.32  | 0.6396           | 0.6378 | + 18    | 45            | 0.4046           | 0.4074 | — 28    |  |
| 24            | 22.23  | 0.5546           | 0.5514 | + 32    | 43            | 0.9442           | 0.9442 | 0       |  |
| $x$ reversed. |        |                  |        |         | $y$ reversed. |                  |        |         |  |
| 4             | 24.23  | 0.6959           | 0.6980 | —0.0021 | 45            | 0.6011           | 0.6052 | —0.0041 |  |
| 5             | 25.24  | 0.2126           | 0.2171 | — 45    | 3             | 0.2530           | 0.2545 | — 15    |  |
| 6             | 31.30  | 0.4008           | 0.4044 | — 36    | 61            | 0.6308           | 0.6295 | + 13    |  |
| 7             | 33.32  | 0.3076           | 0.3701 | — 25    | 50            | 0.7036           | 0.7046 | — 10    |  |
| 8             | 36.35  | 0.3218           | 0.3184 | + 34    | 64            | 0.7136           | 0.7126 | + 10    |  |
| 9             | 36.35  | 0.2922           | 0.2926 | — 4     | 111           | 0.9761           | 0.9775 | — 14    |  |
| 10            | 41.40  | 0.7552           | 0.7578 | — 26    | 113           | 0.9905           | 0.9900 | + 5     |  |
| 14            | 58.57  | 0.1462           | 0.1459 | + 3     | 56            | 0.2334           | 0.2399 | — 65    |  |
| 15            | 58.57  | 0.4220           | 0.4179 | + 41    | 57            | 0.4334           | 0.4339 | — 5     |  |
| 21            | 81.81  | 0.4200           | 0.4195 | + 5     | 55            | 0.8781           | 0.8768 | + 13    |  |
| 22            | 85.84  | 0.7241           | 0.7246 | — 5     | 39            | 0.0398           | 0.0371 | + 27    |  |
| 23            | 87.87  | 0.4181           | 0.4172 | + 9     | 74            | 0.1465           | 0.1449 | + 16    |  |
| 24            | 96.96  | 0.5016           | 0.5068 | — 52    | 75            | 0.6101           | 0.6104 | — 3     |  |

TABLE III. (*Continued.*)—PLATE II.

| Star.         | Lines.   | $\frac{1}{2} m.$ |         | $K-S$    | Lines.        | $\frac{1}{2} m.$ |          | $K-S$    |
|---------------|----------|------------------|---------|----------|---------------|------------------|----------|----------|
|               |          | Kretz.           | Schles. |          |               | Kretz.           | Schles.  |          |
| $x$ direct.   |          |                  |         |          | $y$ direct.   |                  |          |          |
| 1             | 109, 110 | 0.3222           | 0.3191  | + 0.0031 | 81            | 0.5651           | 0.5598   | — 0.0053 |
| 2             | 104, 105 | 0.1171           | 0.1114  | + 57     | 69            | 0.2782           | 0.2772   | + 10     |
| 4             | 84, 85   | 0.4978           | 0.4960  | + 18     | 68            | 0.6494           | 0.6434   | + 60     |
| 5             | 84, 84   | 0.4748           | 0.4745  | + 3      | 111           | — 0.0074         | — 0.0030 | — 44     |
| 6             | 77, 78   | 0.7951           | 0.7892  | + 59     | 52            | 0.6299           | 0.6255   | + 44     |
| 7             | 75, 76   | 0.8240           | 0.8229  | + 11     | 63            | 0.5474           | 0.5496   | — 22     |
| 8             | 72, 73   | 0.8641           | 0.8730  | — 86     | 49            | 0.5369           | 0.5378   | — 9      |
| 9             | 73, 73   | 0.3951           | 0.3972  | — 21     | 2             | 0.2808           | 0.2796   | + 12     |
| 10            | 67, 68   | 0.4310           | 0.4328  | — 18     | 0             | 0.2676           | 0.2674   | + 2      |
| 14            | 51, 52   | 0.0468           | 0.0449  | + 19     | 58            | 0.0136           | 0.0139   | — 3      |
| 15            | 50, 51   | 0.7680           | 0.7676  | + 4      | 56            | 0.8186           | 0.8160   | + 26     |
| 18            | 41, 42   | 0.3262           | 0.3265  | — 3      | 58            | 0.3715           | 0.3725   | — 10     |
| 19            | 36, 36   | 0.4318           | 0.4321  | — 3      | 107           | — 0.0388         | — 0.0448 | + 60     |
| 21            | 27, 28   | 0.2705           | 0.2699  | + 6      | 58            | 0.3766           | 0.3738   | + 8      |
| 22            | 23, 24   | 0.4726           | 0.4718  | + 8      | 75            | 0.2166           | 0.2164   | + 2      |
| 23            | 21, 22   | 0.2770           | 0.2750  | + 20     | 40            | 0.1081           | 0.1054   | + 27     |
| 24            | 12, 13   | 0.1865           | 0.1866  | — 1      | 38            | 0.6466           | 0.6449   | + 17     |
| $x$ reversed. |          |                  |         |          | $y$ reversed. |                  |          |          |
| 1             | 10, 9    | 0.1916           | 0.1865  | + 0.0051 | 37            | 0.9501           | 0.9466   | + 0.0035 |
| 2             | 15, 14   | 0.3998           | 0.4012  | — 14     | 50            | 0.2296           | 0.2289   | + 7      |
| 4             | 34, 34   | 0.5149           | 0.5112  | + 37     | 50            | 0.8618           | 0.8615   | + 3      |
| 5             | 35, 34   | 0.5352           | 0.5318  | + 34     | 8             | 0.5229           | 0.5148   | + 81     |
| 6             | 41, 40   | 0.7226           | 0.7263  | — 37     | 66            | 0.8845           | 0.8831   | + 14     |
| 7             | 43, 42   | 0.6872           | 0.6861  | + 11     | 56            | — 0.0398         | — 0.0384 | — 14     |
| 8             | 46, 45   | 0.6445           | 0.6374  | + 71     | 70            | — 0.0260         | — 0.0265 | + 5      |
| 9             | 46, 45   | 0.6137           | 0.6115  | + 22     | 117           | 0.2348           | 0.2296   | + 52     |
| 10            | 52, 51   | 0.0749           | 0.0749  | 0        | 119           | 0.2450           | 0.2431   | + 19     |
| 14            | 68, 67   | 0.4621           | 0.4608  | + 13     | 61            | 0.4900           | 0.4914   | — 14     |
| 15            | 68, 67   | 0.7396           | 0.7420  | — 24     | 62            | 0.6924           | 0.6926   | — 2      |
| 18            | 78, 77   | 0.1881           | 0.1882  | — 1      | 61            | 0.1391           | 0.1389   | + 2      |
| 19            | 83, 82   | 0.5800           | 0.5809  | — 9      | 12            | 0.5583           | 0.5582   | + 1      |
| 21            | 92, 91   | 0.2399           | 0.2405  | — 6      | 61            | 0.1346           | 0.1311   | + 35     |
| 22            | 96, 95   | 0.0405           | 0.0419  | — 14     | 44            | 0.2921           | 0.2926   | — 5      |
| 23            | 98, 97   | 0.2358           | 0.2375  | — 17     | 79            | 0.4069           | 0.4035   | + 34     |
| 24            | 107, 106 | 0.3200           | 0.3246  | — 46     | 80            | 0.8695           | 0.8689   | + 6      |

TABLE III. (*Continued.*)—PLATE III.

| Star.              | Lines.   | $\frac{1}{2} m.$ |         | $K-S$   | Lines.             | $\frac{1}{2} m.$ |         | $K-S$   |  |
|--------------------|----------|------------------|---------|---------|--------------------|------------------|---------|---------|--|
|                    |          | Kretz.           | Schles. |         |                    | Kretz.           | Schles. |         |  |
| $\alpha$ direct.   |          |                  |         |         | $\gamma$ direct.   |                  |         |         |  |
| 1                  | 116, 116 | 0.5070           | 0.5065  | +0.0005 | 85                 | 0.9316           | 0.9309  | +0.0007 |  |
| 2                  | 110, 111 | 0.8131           | 0.8084  | + 47    | 73                 | 0.6518           | 0.6500  | + 18    |  |
| 4                  | 91, 92   | 0.1970           | 0.1962  | + 8     | 73                 | 0.0194           | 0.0180  | + 14    |  |
| 5                  | 90, 91   | 0.6749           | 0.6722  | + 27    | 115                | 0.3639           | 0.3660  | + 21    |  |
| 6                  | 84, 85   | 0.4969           | 0.4946  | + 23    | 57                 | —0.0051          | —0.0054 | + 3     |  |
| 7                  | 82, 83   | 0.5234           | 0.5195  | + 39    | 67                 | 0.9208           | 0.9190  | + 18    |  |
| 8                  | 79, 80   | 0.5730           | 0.5731  | — 1     | 53                 | 0.9079           | 0.9082  | + 3     |  |
| 9                  | 79, 80   | 0.5951           | 0.5922  | + 29    | 6                  | 0.6519           | 0.6530  | — 11    |  |
| 10                 | 74, 75   | 0.1288           | 0.1288  | 0 4     | 4                  | 0.6448           | 0.6406  | + 42    |  |
| 14                 | 57, 58   | 0.7422           | 0.7394  | + 28    | 62                 | 0.3859           | 0.3840  | + 19    |  |
| 15                 | 57, 58   | 0.4645           | 0.4675  | — 30    | 61                 | 0.1888           | 0.1878  | + 10    |  |
| 21                 | 34, 34   | 0.4712           | 0.4708  | + 4     | 62                 | 0.7505           | 0.7478  | + 27    |  |
| 22                 | 30, 31   | 0.1702           | 0.1684  | + 18    | 79                 | 0.5940           | 0.5902  | + 38    |  |
| 23                 | 28, 28   | 0.4714           | 0.4679  | + 35    | 44                 | 0.4828           | 0.4774  | + 54    |  |
| 24                 | 19, 19   | 0.3875           | 0.3856  | + 19    | 43                 | 0.0195           | 0.0198  | — 3     |  |
| $\alpha$ reversed. |          |                  |         |         | $\gamma$ reversed. |                  |         |         |  |
| 1                  | 3, 2     | 0.5656           | 0.5621  | +0.0035 | 33                 | 0.6416           | 0.6449  | —0.0033 |  |
| 2                  | 8, 7     | 0.7625           | 0.7560  | + 65    | 45                 | 0.9195           | 0.9190  | + 5     |  |
| 4                  | 28, 27   | 0.3736           | 0.3711  | + 25    | 46                 | 0.5540           | 0.5538  | + 2     |  |
| 5                  | 28, 28   | 0.3989           | 0.3935  | + 54    | 4                  | 0.2090           | 0.2090  | 0 0     |  |
| 6                  | 35, 34   | 0.0826           | 0.0760  | + 66    | 62                 | 0.5754           | 0.5756  | — 2     |  |
| 7                  | 36, 36   | 0.5492           | 0.5460  | + 32    | 51                 | 0.6492           | 0.6498  | — 6     |  |
| 8                  | 39, 39   | 0.5010           | 0.4986  | + 24    | 65                 | 0.6604           | 0.6605  | — 1     |  |
| 9                  | 39, 39   | 0.4818           | 0.4766  | + 52    | 112                | 0.9208           | 0.9200  | + 8     |  |
| 10                 | 45, 44   | 0.4419           | 0.4390  | + 29    | 114                | 0.9326           | 0.9286  | + 40    |  |
| 14                 | 61, 60   | 0.8256           | 0.8236  | + 20    | 57                 | 0.1814           | 0.1792  | + 22    |  |
| 15                 | 62, 61   | 0.1035           | 0.1006  | + 29    | 58                 | 0.3782           | 0.3768  | + 14    |  |
| 21                 | 85, 84   | 0.6011           | 0.5996  | + 15    | 56                 | 0.8181           | 0.8159  | + 22    |  |
| 22                 | 89, 88   | 0.4022           | 0.4001  | + 21    | 40                 | —0.0210          | —0.0250 | + 40    |  |
| 23                 | 91, 90   | 0.5974           | 0.5976  | — 2     | 75                 | 0.0886           | 0.0876  | + 10    |  |
| 24                 | 100, 99  | 0.6880           | 0.6824  | + 56    | 76                 | 0.5479           | 0.5479  | 0 0     |  |

TABLE III. (*Continued.*)—PLATE IV.

| Star.         | Lines.  | $\frac{1}{2} m.$ |        | $S-H$   | Lines.        | $\frac{1}{2} m.$ |         | $K-S$   |  |
|---------------|---------|------------------|--------|---------|---------------|------------------|---------|---------|--|
|               |         | Schles.          | Hays.  |         |               | Kretz.           | Schles. |         |  |
| $x$ direct.   |         |                  |        |         | $y$ direct.   |                  |         |         |  |
| 1             | 118,119 | 0.4700           | 0.4716 | —0.0016 | 83            | 0.2781           | 0.2758  | +0.0023 |  |
| 2             | 113,114 | 0.2735           | 0.2761 | — 26    | 71            | —0.0101          | —0.0068 | — 33    |  |
| 4             | 93,94   | 0.6708           | 0.6728 | — 20    | 70            | 0.3578           | 0.3600  | — 22    |  |
| 5             | 93,94   | 0.1411           | 0.1446 | — 35    | 112           | 0.7045           | 0.7004  | + 41    |  |
| 6             | 86,88   | 0.4535           | 0.4565 | — 30    | 54            | 0.3285           | 0.3298  | — 13    |  |
| 7             | 84,86   | 0.4828           | 0.4828 | 0       | 65            | 0.2506           | 0.2539  | — 33    |  |
| 8             | 81,83   | 0.5298           | 0.5262 | + 36    | 51            | 0.2400           | 0.2400  | 0       |  |
| 9             | 82,83   | 0.0775           | 0.0768 | + 7     | 4             | —0.0080          | —0.0061 | — 19    |  |
| 10            | 76,77   | 0.5935           | 0.5918 | + 17    | 1             | 0.9744           | 0.9730  | + 14    |  |
| 11            | 71,72   | 0.8395           | 0.8460 | — 65    | 111           | 0.6095           | 0.6126  | — 31    |  |
| 12            | 70,71   | 0.6272           | 0.6318 | — 46    | 107           | 0.5810           | 0.5826  | — 16    |  |
| 13            | 68,69   | 0.5621           | 0.5626 | — 5     | 48            | 0.8211           | 0.8216  | — 5     |  |
| 14            | 60,61   | 0.2109           | 0.2148 | — 39    | 59            | 0.7249           | 0.7219  | + 30    |  |
| 15            | 59,60   | 0.9259           | 0.9291 | — 32    | 58            | 0.5258           | 0.5254  | + 4     |  |
| 17            | 57,58   | 0.3502           | 0.3498 | + 4     | 57            | 0.0292           | 0.0296  | — 4     |  |
| 18            | 50,51   | 0.4846           | 0.4821 | + 25    | 60            | 0.0790           | 0.0776  | + 14    |  |
| 21            | 36,37   | 0.4294           | 0.4329 | — 35    | 60            | 0.0844           | 0.0865  | — 21    |  |
| 22            | 32,33   | 0.6365           | 0.6395 | — 30    | 76            | 0.9259           | 0.9246  | + 13    |  |
| 23            | 30,31   | 0.4354           | 0.4361 | — 7     | 41            | 0.8180           | 0.8156  | + 24    |  |
| 24            | 21,22   | 0.3508           | 0.3486 | + 22    | 40            | 0.3479           | 0.3490  | — 11    |  |
| $x$ reversed. |         |                  |        |         | $y$ reversed. |                  |         |         |  |
| 1             | 1,0     | 0.0846           | 0.0895 | —0.0049 | 36            | 0.2765           | 0.2790  | —0.0025 |  |
| 2             | 6,5     | 0.2852           | 0.2871 | — 19    | 48            | 0.5614           | 0.5630  | — 16    |  |
| 4             | 25,24   | 0.8882           | 0.8919 | — 37    | 49            | 0.1934           | 0.1936  | — 2     |  |
| 5             | 26,25   | 0.4154           | 0.4218 | — 64    | 6             | 0.8602           | 0.8589  | + 13    |  |
| 6             | 32,31   | 0.6021           | 0.6022 | — 1     | 65            | 0.2199           | 0.2210  | — 11    |  |
| 7             | 34,33   | 0.5736           | 0.5752 | — 16    | 54            | 0.2955           | 0.2970  | — 15    |  |
| 8             | 37,36   | 0.5251           | 0.5299 | — 48    | 68            | 0.3081           | 0.3115  | — 34    |  |
| 9             | 37,36   | 0.4779           | 0.4831 | — 52    | 115           | 0.5664           | 0.5635  | + 29    |  |
| 10            | 43,41   | 0.4641           | 0.4698 | — 57    | 117           | 0.5829           | 0.5851  | — 22    |  |
| 11            | 47,46   | 0.7145           | 0.7108 | + 37    | 7             | 0.9441           | 0.9512  | — 71    |  |
| 12            | 49,47   | 0.4170           | 0.4244 | — 74    | 12,11         | 0.4719           | 0.4751  | — 32    |  |
| 13            | 51,49   | 0.4945           | 0.4948 | — 3     | 70            | 0.7345           | 0.7340  | + 5     |  |
| 14            | 59,58   | 0.3461           | 0.3482 | — 21    | 59            | 0.8324           | 0.8289  | + 35    |  |
| 15            | 59,58   | 0.6271           | 0.6268 | + 3     | 61            | 0.0232           | 0.0246  | — 14    |  |
| 17            | 62,61   | 0.2054           | 0.2031 | + 23    | 62            | 0.5225           | 0.5241  | — 16    |  |
| 18            | 69,67   | 0.5735           | 0.5744 | — 9     | 59            | 0.4738           | 0.4741  | — 3     |  |
| 21            | 83,82   | 0.1235           | 0.1282 | — 47    | 59            | 0.4699           | 0.4664  | + 35    |  |
| 22            | 86,85   | 0.9219           | 0.9259 | — 40    | 42            | 0.6320           | 0.6295  | + 25    |  |
| 23            | 89,88   | 0.1218           | 0.1261 | — 43    | 77            | 0.7371           | 0.7379  | — 8     |  |
| 24            | 98,97   | 0.2104           | 0.2081 | + 23    | 79            | 0.2026           | 0.2044  | — 18    |  |

TABLE III. (*Continued.*)—PLATE V.

| Star.         | Lines.   | $\frac{1}{2} m.$ |        | $S-H$   | Lines.        | $\frac{1}{2} m.$ |         | $K-S$   |   |    |
|---------------|----------|------------------|--------|---------|---------------|------------------|---------|---------|---|----|
|               |          | Schles.          | Hays.  |         |               | Kretz.           | Schles. |         |   |    |
| $x$ direct.   |          |                  |        |         | $y$ direct.   |                  |         |         |   |    |
| 1             | 115, 116 | 0.2261           | 0.2268 | —0.0007 | 85            | 0.7995           | 0.8002  | —0.0007 |   |    |
| 2             | 109, 111 | 0.5240           | 0.5236 | +       | 4             | 73               | 0.5135  | 0.5142  | — | 7  |
| 4             | 90, 91   | 0.4206           | 0.4204 | +       | 2             | 72               | 0.8872  | 0.8888  | — | 16 |
| 5             | 89, 91   | 0.4045           | 0.4066 | —       | 21            | 115              | 0.2265  | 0.2236  | + | 29 |
| 6             | 83, 84   | 0.6962           | 0.6939 | +       | 23            | 56               | 0.8581  | 0.8618  | — | 37 |
| 7             | 81, 82   | 0.7296           | 0.7294 | +       | 2             | 67               | 0.7849  | 0.7885  | — | 36 |
| 8             | 78, 79   | 0.7772           | 0.7774 | —       | 2             | 53               | 0.7720  | 0.7732  | — | 12 |
| 9             | 78, 79   | 0.8032           | 0.8065 | —       | 33            | 6                | 0.5272  | 0.5360  | — | 88 |
| 10            | 73, 74   | 0.3180           | 0.3185 | —       | 5             | 4                | 0.5096  | 0.5076  | + | 20 |
| 13            | 65, 66   | 0.3105           | 0.3055 | +       | 50            | 51               | 0.3511  | 0.3536  | — | 25 |
| 14            | 56, 58   | 0.4566           | 0.4585 | —       | 19            | 62               | 0.2589  | 0.2630  | — | 41 |
| 15            | 56, 57   | 0.6715           | 0.6672 | +       | 43            | 61               | 0.0624  | 0.0628  | — | 4  |
| 18            | 47, 48   | 0.2350           | 0.2282 | +       | 68            | 62               | 0.6159  | 0.6186  | — | 27 |
| 19            | 41, 43   | 0.3604           | 0.3534 | +       | 70            | 111              | 0.2069  | 0.2090  | — | 21 |
| 21            | 33, 34   | 0.1815           | 0.1802 | +       | 13            | 62               | 0.6270  | 0.6274  | — | 4  |
| 22            | 29, 30   | 0.3908           | 0.3906 | +       | 2             | 79               | 0.4705  | 0.4711  | — | 6  |
| 23            | 27, 28   | 0.1711           | 0.1735 | —       | 24            | 44               | 0.3638  | 0.3628  | + | 10 |
| 24            | 17, 19   | 0.5915           | 0.5939 | —       | 24            | 42               | 0.9019  | 0.8999  | + | 20 |
| $x$ reversed. |          |                  |        |         | $y$ reversed. |                  |         |         |   |    |
| 1             | 4, 3     | 0.3330           | 0.3339 | —0.0009 | 33            | 0.7594           | 0.7622  | —0.0028 |   |    |
| 2             | 9, 8     | 0.5400           | 0.5378 | +       | 22            | 46               | 0.0390  | 0.0434  | — | 44 |
| 4             | 29, 27   | 0.6365           | 0.6371 | —       | 6             | 46               | 0.6656  | 0.6660  | — | 4  |
| 5             | 29, 28   | 0.6520           | 0.6514 | +       | 6             | 4                | 0.3330  | 0.3359  | — | 29 |
| 6             | 36, 34   | 0.3590           | 0.3569 | +       | 21            | 62               | 0.6899  | 0.6949  | — | 50 |
| 7             | 37, 36   | 0.8251           | 0.8231 | +       | 20            | 51               | 0.7635  | 0.7660  | — | 25 |
| 8             | 40, 39   | 0.7809           | 0.7778 | +       | 31            | 65               | 0.7822  | 0.7830  | — | 8  |
| 9             | 40, 39   | 0.7532           | 0.7451 | +       | 81            | 113              | 0.0280  | 0.0308  | — | 28 |
| 10            | 46, 45   | 0.2345           | 0.2326 | +       | 19            | 115              | 0.0494  | 0.0528  | — | 34 |
| 13            | 54, 53   | 0.2450           | 0.2419 | +       | 31            | 68               | 0.1968  | 0.2010  | — | 42 |
| 14            | 62, 61   | 0.5984           | 0.6021 | —       | 37            | 57               | 0.2891  | 0.2915  | — | 24 |
| 15            | 63, 61   | 0.3809           | 0.3814 | —       | 5             | 58               | 0.4870  | 0.4908  | — | 38 |
| 18            | 72, 71   | 0.3238           | 0.3229 | +       | 9             | 56               | 0.9359  | 0.9369  | — | 10 |
| 19            | 77, 76   | 0.6992           | 0.6949 | +       | 43            | 8                | 0.3502  | 0.3486  | + | 16 |
| 21            | 86, 85   | 0.3746           | 0.3775 | —       | 29            | 56               | 0.9240  | 0.9221  | + | 19 |
| 22            | 90, 89   | 0.1672           | 0.1664 | +       | 8             | 40               | 0.0851  | 0.0895  | — | 44 |
| 23            | 92, 91   | 0.3808           | 0.3812 | —       | 4             | 75               | 0.1881  | 0.1884  | — | 3  |
| 24            | 101, 100 | 0.4659           | 0.4635 | +       | 24            | 76               | 0.6459  | 0.6496  | — | 31 |



TABLE III. (*Continued.*)—PLATE VI.

| Star.         | Lines.   | $\frac{1}{2} m.$ |        | $K-H$   | Lines.        | $\frac{1}{2} m.$ |        | $S-H$   |  |
|---------------|----------|------------------|--------|---------|---------------|------------------|--------|---------|--|
|               |          | Kretz.           | Hays.  |         |               | Schles.          | Hays.  |         |  |
| $x$ direct.   |          |                  |        |         | $y$ direct.   |                  |        |         |  |
| 1             | 108, 109 | 0.4039           | 0.4035 | +0.0004 | 83            | 0.3775           | 0.3790 | -0.0015 |  |
| 2             | 103, 104 | 0.2052           | 0.2094 | — 42    | 71            | 0.0911           | 0.0954 | — 43    |  |
| 3             | 100, 101 | 0.2099           | 0.2155 | — 56    | 6             | 0.5601           | 0.5598 | + 3     |  |
| 4             | 83, 84   | 0.6019           | 0.6041 | — 22    | 70            | 0.4624           | 0.4628 | — 4     |  |
| 5             | 83, 84   | 0.0738           | 0.0730 | — 8     | 112           | 0.7955           | 0.8022 | — 67    |  |
| 6             | 76, 77   | 0.8864           | 0.8860 | — 4     | 54            | 0.4332           | 0.4295 | + 37    |  |
| 7             | 74, 75   | 0.9162           | 0.9200 | — 38    | 65            | 0.3599           | 0.3596 | + 3     |  |
| 8             | 72, 72   | 0.4651           | 0.4605 | — 46    | 51            | 0.3445           | 0.3444 | + 1     |  |
| 9             | 72, 72   | 0.5165           | 0.5169 | — 4     | 4             | 0.1045           | 0.0974 | — 71    |  |
| 10            | 66, 67   | 0.5305           | 0.5314 | — 9     | 2             | 0.0802           | 0.0798 | + 4     |  |
| 11            | 61, 62   | 0.7779           | 0.7809 | — 30    | 111           | 0.6935           | 0.6916 | + 19    |  |
| 12            | 60, 61   | 0.5730           | 0.5716 | — 14    | 107           | 0.6829           | 0.6781 | + 48    |  |
| 13            | 58, 59   | 0.5006           | 0.4998 | — 8     | 48            | 0.9215           | 0.9231 | — 16    |  |
| 14            | 50, 51   | 0.1418           | 0.1478 | — 60    | 59            | 0.8246           | 0.8249 | — 3     |  |
| 15            | 49, 50   | 0.8639           | 0.8629 | + 10    | 58            | 0.6245           | 0.6245 | 0       |  |
| 16            | 49, 49   | 0.5028           | 0.5054 | — 26    | 112           | 0.6254           | 0.6255 | — 1     |  |
| 18            | 40, 41   | 0.4202           | 0.4204 | — 2     | 60            | 0.1758           | 0.1750 | + 8     |  |
| 19            | 35, 35   | 0.5236           | 0.5259 | — 23    | 108           | 0.7605           | 0.7596 | + 9     |  |
| 21            | 26, 27   | 0.3728           | 0.3754 | — 26    | 60            | 0.1838           | 0.1825 | + 13    |  |
| 22            | 22, 23   | 0.5738           | 0.5756 | — 18    | 77            | 0.0212           | 0.0242 | — 30    |  |
| 23            | 20, 21   | 0.3765           | 0.3769 | — 4     | 41            | 0.9145           | 0.9141 | + 4     |  |
| 24            | 11, 12   | 0.2912           | 0.2910 | — 2     | 40            | 0.4502           | 0.4441 | + 61    |  |
| $x$ reversed. |          |                  |        |         | $y$ reversed. |                  |        |         |  |
| 1             | 11, 10   | 0.1544           | 0.1574 | -0.0030 | 36            | 0.1738           | 0.1748 | -0.0010 |  |
| 2             | 16, 15   | 0.3540           | 0.3584 | — 44    | 48            | 0.4608           | 0.4610 | — 2     |  |
| 3             | 19, 18   | 0.3451           | 0.3430 | — 21    | 112           | 1.0018           | 1.0020 | — 2     |  |
| 4             | 35, 35   | 0.4509           | 0.4535 | — 26    | 49            | 0.0911           | 0.0928 | — 17    |  |
| 5             | 36, 35   | 0.4808           | 0.4821 | — 13    | 6             | 0.7624           | 0.7639 | — 15    |  |
| 6             | 42, 41   | 0.6659           | 0.6692 | — 33    | 65            | 0.1210           | 0.1178 | + 32    |  |
| 7             | 44, 43   | 0.6381           | 0.6386 | — 5     | 54            | 0.1946           | 0.1928 | + 18    |  |
| 8             | 47, 46   | 0.5934           | 0.5925 | — 9     | 68            | 0.2096           | 0.2096 | 0       |  |
| 9             | 47, 46   | 0.5404           | 0.5445 | — 41    | 115           | 0.4552           | 0.4605 | — 53    |  |
| 10            | 52, 52   | 0.5254           | 0.5291 | — 37    | 117           | 0.4781           | 0.4802 | — 21    |  |
| 11            | 57, 56   | 0.7724           | 0.7765 | — 41    | 7             | 0.8656           | 0.8702 | — 46    |  |
| 12            | 58, 58   | 0.4824           | 0.4835 | — 11    | 11            | 0.8765           | 0.8738 | + 27    |  |
| 13            | 60, 60   | 0.5508           | 0.5525 | — 17    | 70            | 0.6330           | 0.6349 | — 19    |  |
| 14            | 69, 68   | 0.4116           | 0.4149 | — 33    | 59            | 0.7334           | 0.7321 | + 13    |  |
| 15            | 69, 68   | 0.6888           | 0.6909 | — 21    | 60            | 0.9284           | 0.9309 | — 25    |  |
| 16            | 70, 69   | 0.5455           | 0.5475 | — 20    | 6             | 0.9312           | 0.9289 | + 23    |  |
| 18            | 79, 78   | 0.1361           | 0.1374 | — 13    | 59            | 0.3772           | 0.3775 | — 3     |  |
| 19            | 84, 83   | 0.5319           | 0.5295 | — 24    | 10            | 0.7975           | 0.7902 | + 73    |  |
| 21            | 93, 92   | 0.1822           | 0.1821 | — 1     | 59            | 0.3699           | 0.3740 | — 41    |  |
| 22            | 96, 96   | 0.4872           | 0.4868 | — 4     | 42            | 0.5330           | 0.5351 | — 21    |  |
| 23            | 99, 98   | 0.1809           | 0.1839 | — 30    | 77            | 0.6421           | 0.6422 | — 1     |  |
| 24            | 108, 107 | 0.2648           | 0.2669 | — 21    | 79            | 0.1089           | 0.1092 | — 3     |  |

TABLE III. (*Continued.*)—PLATE VII.

| Star.              | Lines.  | $\frac{1}{2} m.$ |         | $K-S$    |  | Lines.             | $\frac{1}{2} m.$ |         | $K-S$    |    |
|--------------------|---------|------------------|---------|----------|--|--------------------|------------------|---------|----------|----|
|                    |         | Kretz.           | Schles. |          |  |                    | Kretz.           | Schles. |          |    |
| $\alpha$ direct.   |         |                  |         |          |  | $\gamma$ direct.   |                  |         |          |    |
| 1                  | 118,119 | 0.7175           | 0.7142  | +0.0033  |  | 85                 | 0.9712           | 0.9705  | --0.0007 |    |
| 2                  | 113,114 | 0.5238           | 0.5225  | +13      |  | 73                 | 0.6826           | 0.6838  | --       | 12 |
| 4                  | 94,91   | 0.4214           | 0.4170  | +44      |  | 73                 | 0.0458           | 0.0469  | --       | 11 |
| 5                  | 93,94   | 0.3831           | 0.3849  | --18     |  | 115                | 0.3884           | 0.3870  | +        | 14 |
| 6                  | 87,88   | 0.2078           | 0.2098  | --20     |  | 57                 | 0.0156           | 0.0158  | --       | 2  |
| 7                  | 85,86   | 0.2355           | 0.2318  | +37      |  | 67                 | 0.9426           | 0.9434  | --       | 8  |
| 8                  | 82,83   | 0.2759           | 0.2721  | +38      |  | 53                 | 0.9305           | 0.9306  | --       | 1  |
| 9                  | 82,83   | 0.3330           | 0.3280  | +50      |  | 6                  | 0.6925           | 0.6828  | --       | 3  |
| 10                 | 77,77   | 0.3504           | 0.3474  | +30      |  | 4                  | 0.6578           | 0.6596  | --       | 18 |
| 14                 | 60,61   | 0.4558           | 0.4509  | +49      |  | 62                 | 0.4055           | 0.4084  | --       | 29 |
| 15                 | 60,61   | 0.1725           | 0.1729  | --4      |  | 61                 | 0.2050           | 0.2042  | --       | 8  |
| 18                 | 50,51   | 0.7419           | 0.7434  | --15     |  | 62                 | 0.7575           | 0.7580  | --       | 5  |
| 21                 | 36,37   | 0.6810           | 0.6825  | --15     |  | 62                 | 0.7646           | 0.7655  | --       | 9  |
| 22                 | 33,33   | 0.3751           | 0.3748  | +3       |  | 79                 | 0.6116           | 0.6068  | --       | 48 |
| 23                 | 30,31   | 0.6852           | 0.6844  | +8       |  | 44                 | 0.4926           | 0.4905  | --       | 21 |
| 24                 | 21,22   | 0.6051           | 0.6018  | +33      |  | 43                 | 0.0265           | 0.0281  | --       | 16 |
| $\alpha$ reversed. |         |                  |         |          |  | $\gamma$ reversed. |                  |         |          |    |
| 1                  | 0,0     | 0.3394           | 0.3405  | --0.0011 |  | 33                 | 0.5938           | 0.5942  | --0.0004 |    |
| 2                  | 5,5     | 0.5374           | 0.5376  | --2      |  | 45                 | 0.8719           | 0.8749  | --       | 30 |
| 4                  | 25,24   | 0.6389           | 0.6395  | --9      |  | 46                 | 0.5026           | 0.5050  | --       | 24 |
| 5                  | 26,25   | 0.1679           | 0.1718  | --39     |  | 4                  | 0.1749           | 0.1741  | --       | 8  |
| 6                  | 32,31   | 0.3446           | 0.3458  | --12     |  | 62                 | 0.5366           | 0.5362  | --       | 4  |
| 7                  | 34,33   | 0.3240           | 0.3190  | +50      |  | 51                 | 0.6095           | 0.6111  | --       | 16 |
| 8                  | 37,36   | 0.2735           | 0.2774  | --39     |  | 65                 | 0.6254           | 0.6261  | --       | 7  |
| 9                  | 37,36   | 0.2244           | 0.2209  | +35      |  | 112                | 0.8749           | 0.8729  | +        | 20 |
| 10                 | 42,41   | 0.7056           | 0.7065  | --9      |  | 114                | 0.9016           | 0.9016  | --       | 0  |
| 14                 | 58,58   | 0.6011           | 0.6032  | --21     |  | 57                 | 0.1438           | 0.1438  | --       | 0  |
| 15                 | 59,58   | 0.3750           | 0.3762  | --12     |  | 58                 | 0.3458           | 0.3449  | +        | 9  |
| 18                 | 60,67   | 0.8122           | 0.8138  | --16     |  | 56                 | 0.7986           | 0.7960  | --       | 26 |
| 21                 | 82,82   | 0.3702           | 0.3689  | +13      |  | 56                 | 0.7929           | 0.7918  | +        | 11 |
| 22                 | 86,85   | 0.6841           | 0.6814  | +27      |  | 39                 | 0.9502           | 0.9508  | --       | 6  |
| 23                 | 88,88   | 0.3674           | 0.3689  | --15     |  | 75                 | 0.0615           | 0.0609  | +        | 6  |
| 24                 | 97,97   | 0.4525           | 0.4514  | +11      |  | 76                 | 0.5214           | 0.5212  | --       | 2  |

TABLE III. (*Continued.*)—PLATE VIII.

| Star.         | Lines.   | $\frac{1}{2} m.$ |         | $K-S$    | Lines.        | $\frac{1}{2} m.$ |          | $K-S$    |  |
|---------------|----------|------------------|---------|----------|---------------|------------------|----------|----------|--|
|               |          | Kretz.           | Schles. |          |               | Kretz.           | Schles.  |          |  |
| $x$ direct.   |          |                  |         |          | $y$ direct.   |                  |          |          |  |
| I             | 116, 116 | 0.5630           | 0.5622  | + 0.0008 | 83            | 0.6561           | 0.6550   | + 0.0011 |  |
| 2             | 111, 111 | 0.3661           | 0.3639  | + 22     | 71            | 0.3644           | 0.3656   | — 12     |  |
| 4             | 91, 92   | 0.2635           | 0.2630  | + 5      | 70            | 0.7318           | 0.7302   | + 16     |  |
| 5             | 90, 91   | 0.7289           | 0.7279  | + 10     | 113           | 0.0761           | 0.0705   | + 56     |  |
| 6             | 84, 85   | 0.5426           | 0.5419  | + 7      | 54            | 0.7049           | 0.7035   | + 14     |  |
| 7             | 82, 83   | 0.5731           | 0.5700  | + 31     | 65            | 0.6281           | 0.6262   | + 19     |  |
| 8             | 79, 80   | 0.6232           | 0.6205  | + 27     | 51            | 0.6125           | 0.6106   | + 19     |  |
| 9             | 79, 80   | 0.6764           | 0.6710  | + 54     | 4             | 0.3662           | 0.3719   | — 57     |  |
| 10            | 74, 75   | 0.1859           | 0.1860  | — 1      | 2             | 0.3440           | 0.3434   | + 6      |  |
| 11            | 69, 70   | 0.4272           | 0.4305  | — 33     | 112           | — 0.0295         | — 0.0312 | + 17     |  |
| 12            | 68, 69   | 0.2214           | 0.2188  | + 26     | 107           | 0.9535           | 0.9536   | — 1      |  |
| 13            | 66, 67   | 0.1528           | 0.1571  | — 43     | 49            | 0.1891           | 0.1875   | + 16     |  |
| 14            | 58, 58   | 0.3009           | 0.3008  | + 1      | 60            | 0.0911           | 0.0905   | + 6      |  |
| 15            | 57, 58   | 0.5149           | 0.5130  | + 19     | 58            | 0.8935           | 0.8932   | + 3      |  |
| 16            | 56, 57   | 0.6636           | 0.6616  | + 20     | 112           | 0.9059           | 0.9022   | + 37     |  |
| 17            | 55, 55   | 0.4411           | 0.4396  | + 15     | 57            | 0.4011           | 0.4004   | + 7      |  |
| 18            | 48, 48   | 0.5712           | 0.5669  | + 43     | 60            | 0.4465           | 0.4464   | + 1      |  |
| 19            | 42, 43   | 0.6832           | 0.6829  | + 3      | 109           | 0.0374           | 0.0355   | + 19     |  |
| 20            | 39, 40   | 0.6126           | 0.6124  | + 2      | 111           | 0.5058           | 0.5065   | — 7      |  |
| 21            | 34, 34   | 0.5282           | 0.5285  | — 3      | 60            | 0.4538           | 0.4511   | + 27     |  |
| 22            | 30, 31   | 0.2274           | 0.2280  | — 6      | 77            | 0.2902           | 0.2869   | + 33     |  |
| 23            | 28, 28   | 0.5291           | 0.5279  | + 12     | 42            | 0.1801           | 0.1802   | — 1      |  |
| 24            | 19, 19   | 0.4498           | 0.4492  | + 6      | 40            | 0.7191           | 0.7189   | + 2      |  |
| $x$ reversed. |          |                  |         |          | $y$ reversed. |                  |          |          |  |
| I             | 3, 2     | 0.5154           | 0.5120  | + 0.0034 | 35            | 0.9135           | 0.9139   | — 0.0004 |  |
| 2             | 8, 7     | 0.7099           | 0.7104  | — 5      | 48            | 0.2021           | 0.2012   | + 9      |  |
| 4             | 28, 27   | 0.3111           | 0.3072  | + 39     | 48            | 0.8341           | 0.8334   | + 7      |  |
| 5             | 28, 28   | 0.3438           | 0.3440  | — 2      | 6             | 0.5039           | 0.5012   | + 27     |  |
| 6             | 34, 34   | 0.5342           | 0.5294  | + 48     | 64            | 0.8631           | 0.8629   | + 2      |  |
| 7             | 39, 36   | 0.4976           | 0.4985  | — 9      | 53            | 0.9394           | 0.9391   | + 3      |  |
| 8             | 39, 39   | 0.4492           | 0.4491  | + 1      | 67            | 0.9548           | 0.9551   | — 3      |  |
| 9             | 39, 39   | 0.3999           | 0.3996  | + 3      | 115           | 0.2030           | 0.2039   | — 9      |  |
| 10            | 45, 44   | 0.3845           | 0.3824  | + 21     | 117           | 0.2318           | 0.2305   | + 13     |  |
| 11            | 50, 49   | 0.1475           | 0.1406  | + 69     | 7             | 0.6089           | 0.6036   | + 53     |  |
| 12            | 51, 50   | 0.3524           | 0.3534  | — 10     | 11            | 0.6195           | 0.6176   | + 19     |  |
| 13            | 53, 52   | 0.4158           | 0.4142  | + 16     | 70            | 0.3818           | 0.3824   | — 6      |  |
| 14            | 61, 60   | 0.7686           | 0.7654  | + 32     | 59            | 0.4785           | 0.4756   | + 29     |  |
| 15            | 61, 61   | 0.5535           | 0.5546  | — 11     | 60            | 0.6766           | 0.6748   | + 18     |  |
| 16            | 62, 62   | 0.4095           | 0.4076  | + 19     | 6             | 0.6698           | 0.6732   | — 34     |  |
| 17            | 64, 63   | 0.6312           | 0.6302  | + 10     | 62            | 0.1690           | 0.1682   | + 8      |  |
| 18            | 71, 70   | 0.4992           | 0.4965  | + 27     | 59            | 0.1202           | 0.1214   | — 12     |  |
| 19            | 76, 76   | 0.3894           | 0.3898  | — 4      | 10            | 0.5375           | 0.5334   | + 41     |  |
| 20            | 79, 79   | 0.4620           | 0.4609  | + 11     | 8             | 0.0681           | 0.0655   | + 26     |  |
| 21            | 85, 84   | 0.5440           | 0.5438  | + 2      | 59            | 0.1171           | 0.1191   | — 20     |  |
| 22            | 89, 88   | 0.3461           | 0.3421  | + 40     | 42            | 0.2828           | 0.2816   | + 12     |  |
| 23            | 91, 90   | 0.5451           | 0.5404  | + 47     | 77            | 0.3902           | 0.3918   | — 16     |  |
| 24            | 100, 99  | 0.6236           | 0.6238  | — 2      | 78            | 0.8555           | 0.8528   | + 27     |  |

TABLE III. (*Continued.*)—PLATE IX.

| Star.              | Lines.   | $\frac{1}{2} m.$ |         | $K-S$   |    | Lines.             | $\frac{1}{2} m.$ |         | $K-S$   |    |
|--------------------|----------|------------------|---------|---------|----|--------------------|------------------|---------|---------|----|
|                    |          | Kretz.           | Schles. |         |    |                    | Kretz.           | Schles. |         |    |
| $\alpha$ direct.   |          |                  |         |         |    | $\gamma$ direct.   |                  |         |         |    |
| 1                  | 116, 117 | 0.8440           | 0.8381  | +0.0059 |    | 83                 | 0.0719           | 0.0690  | +0.0029 |    |
| 2                  | 111, 112 | 0.6484           | 0.6488  | —       | 4  | 70                 | 0.7826           | 0.7815  | +       | 11 |
| 4                  | 92, 92   | 0.5455           | 0.5451  | +       | 4  | 70                 | 0.1442           | 0.1461  | —       | 19 |
| 5                  | 91, 92   | 0.5022           | 0.5029  | —       | 7  | 112                | 0.4836           | 0.4836  | +       | 0  |
| 7                  | 83, 84   | 0.3648           | 0.3585  | +       | 63 | 65                 | 0.0386           | 0.0366  | +       | 20 |
| 8                  | 80, 81   | 0.4150           | 0.4114  | +       | 36 | 51                 | 0.0261           | 0.0250  | +       | 11 |
| 9                  | 80, 81   | 0.4790           | 0.4750  | +       | 40 | 3                  | 0.7881           | 0.7878  | +       | 3  |
| 10                 | 75, 75   | 0.4909           | 0.4880  | +       | 29 | 1                  | 0.7564           | 0.7569  | —       | 5  |
| 14                 | 58, 59   | 0.5828           | 0.5844  | —       | 16 | 59                 | 0.5016           | 0.5021  | —       | 5  |
| 15                 | 58, 59   | 0.3030           | 0.3036  | —       | 6  | 58                 | 0.3018           | 0.2999  | +       | 19 |
| 21                 | 34, 35   | 0.8115           | 0.8126  | —       | 11 | 59                 | 0.8532           | 0.8526  | +       | 6  |
| 22                 | 31, 31   | 0.5039           | 0.5036  | +       | 3  | 76                 | 0.6914           | 0.6925  | —       | 11 |
| 23                 | 28, 29   | 0.8178           | 0.8199  | —       | 21 | 41                 | 0.5868           | 0.5836  | +       | 32 |
| 24                 | 19, 20   | 0.7445           | 0.7402  | +       | 43 | 40                 | 0.1199           | 0.1209  | —       | 10 |
| $\alpha$ reversed. |          |                  |         |         |    | $\gamma$ reversed. |                  |         |         |    |
| 1                  | 2, 1     | 0.7360           | 0.7349  | +0.0011 |    | 36                 | 0.5056           | 0.5059  | —0.0003 |    |
| 2                  | 7, 7     | 0.4249           | 0.4261  | —       | 12 | 48                 | 0.7891           | 0.7864  | +       | 27 |
| 4                  | 26, 27   | 0.5279           | 0.5260  | +       | 19 | 49                 | 0.4226           | 0.4246  | —       | 20 |
| 5                  | 27, 27   | 0.5700           | 0.5678  | +       | 22 | 7                  | 0.0984           | 0.0915  | +       | 69 |
| 7                  | 36, 35   | 0.2141           | 0.2128  | +       | 13 | 54                 | 0.5351           | 0.5319  | +       | 32 |
| 8                  | 39, 38   | 0.1574           | 0.1611  | —       | 37 | 68                 | 0.5480           | 0.5458  | +       | 22 |
| 9                  | 39, 38   | 0.0960           | 0.0972  | —       | 12 | 115                | 0.7899           | 0.7875  | +       | 24 |
| 10                 | 44, 43   | 0.5809           | 0.5815  | —       | 6  | 117                | 0.8142           | 0.8128  | +       | 14 |
| 14                 | 60, 60   | 0.4910           | 0.4902  | +       | 8  | 60                 | 0.0658           | 0.0691  | —       | 33 |
| 15                 | 61, 60   | 0.2688           | 0.2708  | —       | 20 | 61                 | 0.2671           | 0.2688  | —       | 17 |
| 21                 | 84, 83   | 0.7565           | 0.7591  | —       | 26 | 59                 | 0.7155           | 0.7139  | +       | 16 |
| 22                 | 88, 87   | 0.5665           | 0.5669  | —       | 4  | 42                 | 0.8768           | 0.8768  |         | 0  |
| 23                 | 90, 89   | 0.7518           | 0.7546  | —       | 28 | 78                 | —0.0170          | —0.0150 | —       | 20 |
| 24                 | 99, 98   | 0.8358           | 0.8295  | +       | 63 | 79                 | 0.4514           | 0.4506  | +       | 8  |

TABLE III. (*Continued.*)—PLATE X.

| Star.         | Lines.   | $\frac{1}{2} m.$ |         | $K-S$   |    | Lines.        | $\frac{1}{2} m.$ |         | $K-S$   |    |
|---------------|----------|------------------|---------|---------|----|---------------|------------------|---------|---------|----|
|               |          | Kretz.           | Schles. |         |    |               | Kretz.           | Schles. |         |    |
| $x$ direct.   |          |                  |         |         |    | $y$ direct.   |                  |         |         |    |
| 1             | 113, 114 | 0.3234           | 0.3208  | +0.0026 |    | 86            | 0.2979           | 0.2959  | +0.0020 |    |
| 2             | 108, 109 | 0.1272           | 0.1304  | —       | 32 | 74            | 0.0085           | 0.0106  | —       | 21 |
| 4             | 88, 89   | 0.5262           | 0.5255  | +       | 7  | 73            | 0.3750           | 0.3754  | —       | 4  |
| 5             | 88, 88   | 0.4890           | 0.4862  | +       | 28 | 115           | 0.7070           | 0.7061  | —       | 9  |
| 6             | 81, 82   | 0.8085           | 0.8068  | +       | 17 | 57            | 0.3482           | 0.3474  | +       | 8  |
| 7             | 79, 80   | 0.8375           | 0.8365  | +       | 10 | 68            | 0.2682           | 0.2675  | +       | 7  |
| 8             | 76, 77   | 0.8894           | 0.8885  | +       | 9  | 54            | 0.2530           | 0.2508  | +       | 22 |
| 9             | 77, 77   | 0.4504           | 0.4506  | —       | 2  | 7             | 0.0102           | 0.0132  | —       | 30 |
| 10            | 71, 72   | 0.4591           | 0.4592  | —       | 1  | 5             | —0.0132          | —0.0114 | —       | 18 |
| 14            | 55, 56   | 0.0611           | 0.0642  | —       | 31 | 62            | 0.7330           | 0.7338  | —       | 8  |
| 15            | 54, 55   | 0.7846           | 0.7838  | +       | 8  | 61            | 0.5306           | 0.5309  | —       | 3  |
| 18            | 45, 46   | 0.3384           | 0.3440  | —       | 56 | 63            | 0.0811           | 0.0808  | +       | 3  |
| 21            | 31, 32   | 0.2909           | 0.2924  | —       | 15 | 63            | 0.0885           | 0.0886  | —       | 1  |
| 22            | 27, 28   | 0.4865           | 0.4858  | +       | 7  | 79            | 0.9278           | 0.9288  | —       | 10 |
| 23            | 25, 26   | 0.2966           | 0.2974  | —       | 8  | 44            | 0.8208           | 0.8199  | +       | 9  |
| 24            | 16, 17   | 0.2174           | 0.2150  | +       | 24 | 43            | 0.3552           | 0.3589  | —       | 37 |
| $x$ reversed. |          |                  |         |         |    | $y$ reversed. |                  |         |         |    |
| 1             | 6, 5     | 0.2449           | 0.2476  | —0.0027 |    | 33            | 0.2816           | 0.2811  | +0.0005 |    |
| 2             | 11, 10   | 0.4430           | 0.4445  | —       | 15 | 45            | 0.5610           | 0.5622  | —       | 12 |
| 4             | 31, 30   | 0.0442           | 0.0449  | —       | 7  | 46            | 0.1946           | 0.1944  | +       | 2  |
| 5             | 31, 30   | 0.5838           | 0.5861  | —       | 23 | 3             | 0.8681           | 0.8685  | —       | 4  |
| 6             | 37, 36   | 0.7638           | 0.7629  | +       | 9  | 62            | 0.2221           | 0.2238  | —       | 17 |
| 7             | 39, 38   | 0.7318           | 0.7322  | —       | 4  | 51            | 0.3011           | 0.3025  | —       | 14 |
| 8             | 42, 41   | 0.6811           | 0.6792  | +       | 19 | 65            | 0.3166           | 0.3186  | —       | 20 |
| 9             | 42, 41   | 0.6245           | 0.6168  | +       | 77 | 112           | 0.5606           | 0.5620  | —       | 14 |
| 10            | 48, 47   | 0.1142           | 0.1102  | +       | 40 | 114           | 0.5840           | 0.5858  | —       | 18 |
| 14            | 64, 63   | 0.5032           | 0.5032  | —       | 0  | 56            | 0.8351           | 0.8361  | —       | 10 |
| 15            | 64, 63   | 0.7844           | 0.7795  | +       | 49 | 58            | 0.0371           | 0.0371  | —       | 0  |
| 18            | 74, 73   | 0.2335           | 0.2320  | +       | 15 | 56            | 0.4891           | 0.4886  | +       | 5  |
| 21            | 88, 87   | 0.2800           | 0.2806  | —       | 6  | 56            | 0.4802           | 0.4796  | +       | 6  |
| 22            | 92, 91   | 0.0872           | 0.0886  | —       | 14 | 39            | 0.6421           | 0.6435  | —       | 14 |
| 23            | 94, 93   | 0.2758           | 0.2776  | —       | 18 | 74            | 0.7484           | 0.7470  | +       | 14 |
| 24            | 103, 102 | 0.3649           | 0.3592  | +       | 57 | 76            | 0.2141           | 0.2148  | —       | 7  |

TABLE III. (*Continued.*)—PLATE XI.

| Star.              | Lines.   | $\frac{1}{2} m.$ |         | $K-S$   |  | Lines.             | $\frac{1}{2} m.$ |         | $K-S$   |    |
|--------------------|----------|------------------|---------|---------|--|--------------------|------------------|---------|---------|----|
|                    |          | Kretz.           | Schles. |         |  |                    | Kretz.           | Schles. |         |    |
| $\alpha$ direct.   |          |                  |         |         |  | $\gamma$ direct.   |                  |         |         |    |
| 1                  | 115, 116 | 0.1050           | 0.0976  | +0.0074 |  | 85                 | 0.6549           | 0.6510  | +0.0039 |    |
| 2                  | 109, 110 | 0.9070           | 0.9062  | + 8     |  | 73                 | 0.3641           | 0.3659  | —       | 18 |
| 4                  | 90, 91   | 0.3026           | 0.3010  | + 16    |  | 72                 | 0.7310           | 0.7299  | +       | 11 |
| 5                  | 89, 90   | 0.7635           | 0.7664  | — 29    |  | 115                | 0.0649           | 0.0631  | +       | 18 |
| 6                  | 83, 84   | 0.5946           | 0.5905  | + 41    |  | 56                 | 0.7060           | 0.7035  | +       | 25 |
| 7                  | 81, 82   | 0.6135           | 0.6128  | + 7     |  | 67                 | 0.6280           | 0.6298  | —       | 18 |
| 8                  | 78, 79   | 0.6694           | 0.6629  | + 65    |  | 53                 | 0.6142           | 0.6096  | +       | 46 |
| 9                  | 78, 79   | 0.7289           | 0.7264  | + 25    |  | 6                  | 0.3726           | 0.3706  | +       | 20 |
| 10                 | 73, 74   | 0.2374           | 0.2331  | + 43    |  | 4                  | 0.3458           | 0.3455  | +       | 3  |
| 14                 | 56, 57   | 0.8426           | 0.8400  | + 26    |  | 62                 | 0.0909           | 0.0894  | +       | 15 |
| 15                 | 56, 57   | 0.5632           | 0.5659  | — 27    |  | 60                 | 0.8961           | 0.8946  | +       | 15 |
| 18                 | 47, 48   | 0.1231           | 0.1212  | + 19    |  | 62                 | 0.4459           | 0.4438  | +       | 21 |
| 21                 | 33, 34   | 0.0709           | 0.0698  | + 11    |  | 62                 | 0.4491           | 0.4464  | +       | 27 |
| 22                 | 29, 30   | 0.2689           | 0.2655  | + 34    |  | 79                 | 0.2870           | 0.2869  | +       | 1  |
| 23                 | 27, 28   | 0.0744           | 0.0746  | — 2     |  | 44                 | 0.1779           | 0.1772  | +       | 7  |
| 24                 | 18, 19   | —0.0016          | —0.0060 | + 44    |  | 42                 | 0.7154           | 0.7159  | —       | 5  |
| $\alpha$ reversed. |          |                  |         |         |  | $\gamma$ reversed. |                  |         |         |    |
| 1                  | 4, 3     | 0.4698           | 0.4730  | —0.0032 |  | 33                 | 0.9211           | 0.9220  | —0.0009 |    |
| 2                  | 9, 8     | 0.6674           | 0.6631  | + 43    |  | 46                 | 0.2062           | 0.2078  | —       | 16 |
| 4                  | 29, 28   | 0.2696           | 0.2675  | + 21    |  | 46                 | 0.8368           | 0.8405  | —       | 37 |
| 5                  | 29, 28   | 0.8052           | 0.8049  | + 3     |  | 4                  | 0.5128           | 0.5100  | +       | 28 |
| 6                  | 36, 35   | —0.0194          | —0.0211 | + 17    |  | 62                 | 0.8656           | 0.8645  | +       | 11 |
| 7                  | 38, 36   | 0.4594           | 0.4579  | + 15    |  | 51                 | 0.9416           | 0.9402  | +       | 14 |
| 8                  | 40, 39   | 0.9111           | 0.9076  | + 35    |  | 65                 | 0.9599           | 0.9572  | +       | 27 |
| 9                  | 40, 39   | 0.8484           | 0.8425  | + 59    |  | 113                | 0.2010           | 0.2010  | +       | 0  |
| 10                 | 46, 45   | 0.3371           | 0.3342  | + 29    |  | 115                | 0.2256           | 0.2248  | +       | 8  |
| 14                 | 62, 61   | 0.7290           | 0.7235  | + 55    |  | 57                 | 0.4795           | 0.4734  | +       | 61 |
| 15                 | 63, 62   | 0.0098           | 0.0035  | + 63    |  | 58                 | 0.6739           | 0.6721  | +       | 18 |
| 18                 | 72, 71   | 0.4490           | 0.4468  | + 22    |  | 57                 | 0.1256           | 0.1246  | +       | 10 |
| 21                 | 86, 85   | 0.5012           | 0.5011  | + 1     |  | 57                 | 0.1218           | 0.1222  | —       | 4  |
| 22                 | 90, 89   | 0.3050           | 0.3014  | + 36    |  | 40                 | 0.2834           | 0.2808  | +       | 26 |
| 23                 | 92, 91   | 0.4932           | 0.4959  | — 27    |  | 75                 | 0.3880           | 0.3895  | —       | 15 |
| 24                 | 101, 100 | 0.5831           | 0.5762  | + 69    |  | 76                 | 0.8542           | 0.8540  | +       | 2  |



TABLE III. (*Continued.*)—PLATE XII.

| Star.         | Lines.   | $\frac{1}{2} m.$ |         | $K-S$   | Lines.        | $\frac{1}{2} m.$ |         | $K-S$   |  |
|---------------|----------|------------------|---------|---------|---------------|------------------|---------|---------|--|
|               |          | Kretz.           | Schles. |         |               | Kretz.           | Schles. |         |  |
| $x$ direct.   |          |                  |         |         | $y$ direct.   |                  |         |         |  |
| 1             | 117, 117 | 0.3558           | 0.3552  | +0.0006 | 85            | 0.6570           | 0.6552  | +0.0018 |  |
| 2             | 111, 112 | 0.6516           | 0.6536  | — 20    | 73            | 0.3662           | 0.3661  | + 1     |  |
| 4             | 92, 92   | 0.5559           | 0.5545  | + 14    | 72            | 0.7385           | 0.7341  | + 44    |  |
| 5             | 91, 92   | 0.5270           | 0.5298  | — 28    | 115           | 0.0692           | 0.0678  | + 14    |  |
| 6             | 85, 86   | 0.3406           | 0.3415  | — 9     | 56            | 0.7066           | 0.7070  | — 4     |  |
| 7             | 83, 84   | 0.3695           | 0.3665  | + 30    | 67            | 0.6330           | 0.6314  | + 16    |  |
| 8             | 80, 81   | 0.4196           | 0.4185  | + 11    | 53            | 0.6179           | 0.6179  | 0       |  |
| 9             | 80, 81   | 0.4741           | 0.4686  | + 55    | 6             | 0.3818           | 0.3781  | + 37    |  |
| 10            | 75, 75   | 0.4812           | 0.4772  | + 40    | 4             | 0.3498           | 0.3501  | — 3     |  |
| 14            | 58, 59   | 0.5935           | 0.5900  | + 35    | 62            | 0.0949           | 0.0946  | + 3     |  |
| 15            | 58, 59   | 0.3138           | 0.3139  | — 1     | 60            | 0.8989           | 0.8996  | — 7     |  |
| 18            | 49, 49   | 0.3775           | 0.3780  | — 5     | 62            | 0.4556           | 0.4524  | + 32    |  |
| 21            | 34, 35   | 0.8196           | 0.8184  | + 12    | 62            | 0.4604           | 0.4576  | + 28    |  |
| 22            | 31, 31   | 0.5218           | 0.5176  | + 42    | 79            | 0.2939           | 0.2960  | — 21    |  |
| 23            | 28, 29   | 0.8182           | 0.8201  | — 19    | 44            | 0.1931           | 0.1894  | + 37    |  |
| 24            | 19, 20   | 0.7440           | 0.7414  | + 26    | 42            | 0.7256           | 0.7276  | — 20    |  |
| $x$ reversed. |          |                  |         |         | $y$ reversed. |                  |         |         |  |
| 1             | 2, 1     | 0.7130           | 0.7108  | +0.0022 | 33            | 0.9225           | 0.9211  | +0.0014 |  |
| 2             | 7, 7     | 0.4231           | 0.4170  | + 61    | 46            | 0.2075           | 0.2051  | + 24    |  |
| 4             | 27, 26   | 0.5166           | 0.5126  | + 40    | 46            | 0.8381           | 0.8351  | + 30    |  |
| 5             | 27, 27   | 0.5425           | 0.5418  | + 7     | 4             | 0.5074           | 0.5026  | + 48    |  |
| 6             | 34, 33   | 0.2350           | 0.2334  | + 16    | 62            | 0.8635           | 0.8622  | + 13    |  |
| 7             | 36, 35   | 0.2072           | 0.2038  | + 34    | 51            | 0.9378           | 0.9370  | + 8     |  |
| 8             | 39, 38   | 0.1575           | 0.1542  | + 33    | 65            | 0.9532           | 0.9520  | + 12    |  |
| 9             | 39, 38   | 0.1039           | 0.0998  | + 41    | 113           | 0.2014           | 0.1956  | + 58    |  |
| 10            | 44, 43   | 0.5919           | 0.5888  | + 31    | 115           | 0.2255           | 0.2234  | + 21    |  |
| 14            | 60, 60   | 0.4779           | 0.4751  | + 28    | 57            | 0.4702           | 0.4686  | + 16    |  |
| 15            | 61, 60   | 0.2556           | 0.2520  | + 36    | 58            | 0.6709           | 0.6696  | + 13    |  |
| 18            | 70, 69   | 0.6935           | 0.6954  | — 19    | 57            | 0.1172           | 0.1170  | + 2     |  |
| 21            | 84, 83   | 0.7489           | 0.7474  | + 15    | 57            | 0.1140           | 0.1115  | + 25    |  |
| 22            | 88, 87   | 0.5515           | 0.5468  | + 47    | 40            | 0.2756           | 0.2738  | + 18    |  |
| 23            | 90, 89   | 0.7484           | 0.7478  | + 6     | 75            | 0.3842           | 0.3832  | + 10    |  |
| 24            | 99, 98   | 0.8322           | 0.8305  | + 17    | 76            | 0.8444           | 0.8439  | + 5     |  |

TABLE III. (*Continued.*)—PLATE XIII.

| Star.         | Lines.   | $\frac{1}{2} m.$ |         | $K-S$   | Lines.        | $\frac{1}{2} m.$ |         | $K-S$   |  |
|---------------|----------|------------------|---------|---------|---------------|------------------|---------|---------|--|
|               |          | Kretz.           | Schles. |         |               | Kretz.           | Schles. |         |  |
| $x$ direct.   |          |                  |         |         | $y$ direct.   |                  |         |         |  |
| 1             | 117, 118 | 0.1521           | 0.1500  | +0.0021 | 84            | 0.4056           | 0.4038  | +0.0018 |  |
| 2             | 112, 112 | 0.4571           | 0.4561  | + 10    | 72            | 0.1191           | 0.1161  | + 30    |  |
| 4             | 92, 93   | 0.3555           | 0.3516  | + 39    | 71            | 0.4829           | 0.4791  | + 38    |  |
| 5             | 91, 92   | 0.8075           | 0.8118  | — 43    | 113           | 0.8171           | 0.8115  | + 56    |  |
| 6             | 85, 86   | 0.6416           | 0.6390  | + 26    | 55            | 0.4538           | 0.4540  | — 2     |  |
| 7             | 83, 84   | 0.6654           | 0.6639  | + 15    | 66            | 0.3712           | 0.3728  | — 16    |  |
| 8             | 80, 81   | 0.7216           | 0.7218  | — 2     | 52            | 0.3614           | 0.3610  | + 4     |  |
| 9             | 80, 81   | 0.7885           | 0.7866  | + 19    | 5             | 0.1211           | 0.1236  | — 25    |  |
| 10            | 75, 76   | 0.2985           | 0.2965  | + 20    | 3             | 0.0934           | 0.1000  | — 66    |  |
| 14            | 58, 59   | 0.8888           | 0.8861  | + 27    | 60            | 0.8355           | 0.8332  | + 23    |  |
| 15            | 58, 59   | 0.6098           | 0.6134  | — 36    | 59            | 0.6378           | 0.6356  | + 22    |  |
| 21            | 35, 36   | 0.1186           | 0.1189  | — 3     | 61            | 0.1895           | 0.1888  | + 7     |  |
| 22            | 31, 32   | 0.3111           | 0.3119  | — 8     | 78            | 0.0312           | 0.0274  | + 38    |  |
| 23            | 29, 30   | 0.1250           | 0.1258  | — 8     | 42            | 0.9195           | 0.9172  | + 23    |  |
| 24            | 20, 21   | 0.0474           | 0.0486  | — 12    | 41            | 0.4536           | 0.4536  | 0       |  |
| $x$ reversed. |          |                  |         |         | $y$ reversed. |                  |         |         |  |
| 1             | 2, 1     | 0.4248           | 0.4224  | +0.0024 | 35            | 0.1695           | 0.1682  | +0.0013 |  |
| 2             | 7, 6     | 0.6190           | 0.6181  | + 9     | 47            | 0.4578           | 0.4562  | + 16    |  |
| 4             | 27, 26   | 0.2204           | 0.2159  | + 45    | 48            | 0.0898           | 0.0899  | — 1     |  |
| 5             | 27, 26   | 0.7622           | 0.7606  | + 16    | 5             | 0.7630           | 0.7619  | + 11    |  |
| 6             | 33, 33   | 0.4400           | 0.4396  | + 4     | 64            | 0.1200           | 0.1222  | — 22    |  |
| 7             | 35, 35   | 0.4100           | 0.4096  | + 4     | 53            | 0.2000           | 0.2028  | — 28    |  |
| 8             | 38, 37   | 0.8515           | 0.8515  | 0       | 67            | 0.2120           | 0.2121  | — 1     |  |
| 9             | 38, 37   | 0.7888           | 0.7854  | + 34    | 114           | 0.4490           | 0.4478  | + 12    |  |
| 10            | 44, 43   | 0.2812           | 0.2770  | + 42    | 116           | 0.4812           | 0.4779  | + 33    |  |
| 14            | 60, 59   | 0.6799           | 0.6775  | + 24    | 58            | 0.7315           | 0.7308  | + 7     |  |
| 15            | 60, 60   | 0.4586           | 0.4592  | — 6     | 59            | 0.9350           | 0.9342  | + 8     |  |
| 21            | 84, 83   | 0.4496           | 0.4502  | — 6     | 58            | 0.3815           | 0.3799  | + 16    |  |
| 22            | 88, 87   | 0.2611           | 0.2592  | + 19    | 41            | 0.5430           | 0.5421  | + 9     |  |
| 23            | 90, 89   | 0.4429           | 0.4445  | — 16    | 76            | 0.6502           | 0.6499  | + 3     |  |
| 24            | 99, 98   | 0.5315           | 0.5289  | + 26    | 78            | 0.1174           | 0.1174  | 0       |  |

TABLE III. (*Continued.*)—PLATE XIV.

| Star.         | Lines.   | $\frac{1}{2} m.$ |         | $K-S$   | Lines.        | $\frac{1}{2} m.$ |         | $K-S$   |      |    |
|---------------|----------|------------------|---------|---------|---------------|------------------|---------|---------|------|----|
|               |          | Kretz.           | Schles. |         |               | Kretz.           | Schles. |         |      |    |
| $x$ direct.   |          |                  |         |         | $y$ direct.   |                  |         |         |      |    |
| 1             | 113, 114 | 0.2245           | 0.2214  | +0.0031 | 84            | 0.9181           | 0.9144  | +0.0037 |      |    |
| 2             | 108, 108 | 0.5280           | 0.5268  | +       | 12            | 72               | 0.6308  | 0.6332  | — 24 |    |
| 4             | 88, 89   | 0.4256           | 0.4272  | — 16    | 72            | —0.0031          | —0.0052 | +       | 21   |    |
| 5             | 87, 88   | 0.8855           | 0.8874  | — 19    | 114           | 0.3274           | 0.3272  | +       | 2    |    |
| 6             | 81, 82   | 0.7135           | 0.7152  | — 17    | 56            | —0.0285          | —0.0284 | — 1     |      |    |
| 7             | 79, 80   | 0.7394           | 0.7440  | — 46    | 66            | 0.8921           | 0.8905  | +       | 16   |    |
| 8             | 76, 77   | 0.7885           | 0.7918  | — 33    | 52            | 0.8752           | 0.8766  | — 14    |      |    |
| 9             | 76, 77   | 0.8565           | 0.8554  | +       | 11            | 5                | 0.6408  | 0.6402  | +    | 6  |
| 10            | 71, 72   | 0.3648           | 0.3628  | +       | 20            | 3                | 0.6086  | 0.6088  | — 2  |    |
| 14            | 55, 55   | 0.4655           | 0.4644  | +       | 11            | 61               | 0.3536  | 0.3556  | — 20 |    |
| 15            | 54, 55   | 0.6892           | 0.6925  | — 33    | 60            | 0.1579           | 0.1568  | +       | 11   |    |
| 18            | 45, 46   | 0.2465           | 0.2452  | +       | 13            | 61               | 0.7085  | 0.7068  | +    | 17 |
| 21            | 31, 32   | 0.1939           | 0.1910  | +       | 29            | 61               | 0.7102  | 0.7105  | — 3  |    |
| 22            | 27, 28   | 0.3870           | 0.3869  | +       | 1             | 78               | 0.5519  | 0.5500  | +    | 19 |
| 23            | 25, 26   | 0.1961           | 0.1980  | — 19    | 43            | 0.4438           | 0.4404  | +       | 34   |    |
| 24            | 16, 17   | 0.1186           | 0.1204  | — 18    | 42            | —0.0202          | —0.0190 | — 12    |      |    |
| $x$ reversed. |          |                  |         |         | $y$ reversed. |                  |         |         |      |    |
| 1             | 6, 5     | 0.3469           | 0.3476  | —0.0007 | 34            | 0.6566           | 0.6596  | —0.0030 |      |    |
| 2             | 11, 10   | 0.5432           | 0.5428  | +       | 4             | 46               | 0.9399  | 0.9405  | — 6  |    |
| 4             | 31, 30   | 0.1449           | 0.1436  | +       | 13            | 47               | 0.5769  | 0.5765  | +    | 4  |
| 5             | 31, 30   | 0.6825           | 0.6811  | +       | 14            | 5                | 0.2490  | 0.2472  | +    | 18 |
| 6             | 37, 36   | 0.8592           | 0.8519  | +       | 73            | 63               | 0.6041  | 0.5984  | +    | 57 |
| 7             | 39, 38   | 0.8290           | 0.8301  | — 11    | 52            | 0.6828           | 0.6811  | +       | 17   |    |
| 8             | 42, 41   | 0.7812           | 0.7808  | +       | 4             | 66               | 0.6966  | 0.6958  | +    | 8  |
| 9             | 42, 41   | 0.7201           | 0.7168  | +       | 33            | 113              | 0.9422  | 0.9371  | +    | 51 |
| 10            | 48, 47   | 0.2098           | 0.2056  | +       | 42            | 116              | —0.0358 | —0.0384 | +    | 26 |
| 14            | 64, 63   | 0.6045           | 0.6021  | +       | 24            | 58               | 0.2125  | 0.2099  | +    | 26 |
| 15            | 64, 64   | 0.3796           | 0.3812  | — 16    | 59            | 0.4166           | 0.4150  | +       | 16   |    |
| 18            | 74, 73   | 0.3269           | 0.3275  | — 6     | 57            | 0.8676           | 0.8644  | +       | 32   |    |
| 21            | 88, 87   | 0.3771           | 0.3801  | — 30    | 57            | 0.8635           | 0.8602  | +       | 33   |    |
| 22            | 92, 91   | 0.1838           | 0.1869  | — 31    | 41            | 0.0238           | 0.0232  | +       | 6    |    |
| 23            | 94, 93   | 0.3729           | 0.3749  | — 20    | 76            | 0.1311           | 0.1312  | — 1     |      |    |
| 24            | 103, 102 | 0.4605           | 0.4579  | +       | 26            | 77               | 0.5959  | 0.5958  | +    | 1  |

## II. Instrumental Corrections.

**Division Errors.**—The measured coördinates of any star are the difference in the readings on the scale corresponding to the central star, and those corresponding to the star in question. Hence they depend directly on the distance between two given lines on the scale.\* If this were perfect, an equal number of divisions would represent exactly the same length, no matter what part of the scale were used. That is not the case however, and corrections must therefore be applied to the different lines, so as to reduce all measured distances to a common unit. The unit selected was  $1/130$ th of the total length, that being the number of spaces into which the scale is divided. Each space equals approximately one millimeter.

In the winter of 1896–1897, the scale used for all the Coma measurements was carefully investigated for division errors, Professor Jacoby's method, described by him in the *American Journal of Science*, Vol. I, 1896, p. 333, being followed throughout. The details of the investigation are to be published at a later date by the observatory; I shall give here merely a table of results. A determination of the errors had been made previous to shipping the scale to America, by the *Kaiserliche Normal Aichungs Kommission*, at Berlin. Their results are published in the *Annals of the New York Academy of Sciences*, Vol. IX, p. 206. I decided to exclude them, however, as it was deemed most accurate to use only those results which had been obtained under the same conditions and with the same instrument as all the other observations employed in the reductions. Nor were the quantities as used greatly affected thereby, for the two determinations agree quite well, differing in no case by more than  $0''.11$ . As each star was made to depend on a number of lines, the error introduced

by using an inaccurate value of the division errors was still further reduced.

In the table on p. 423 the corrections, which must be added to the measured  $\frac{1}{2} m$ . with the sign shown, are given in millimeters. The argument is the number of the line. When two lines were used, the mean of the corresponding corrections was applied to  $\frac{1}{2} m$ .

**Corrections for Runs and Screw Errors.**—As has already been stated, observations were made for runs twice a day, once by each observer. A complete observation always consisted of two determinations, made as follows: The screw being set at about 5  $R$  (the  $R$  representing revolutions), the spider-threads were set on the line 70, and the micrometer head was read. Then, without moving the microscope, the screw was turned until the threads bisected line 65, and a reading was taken. Then once more on 65, and back to 70, and the observation was completed. The lines 65 and 70 were selected as they have nearly the same division errors. Since the screw makes two complete revolutions while the threads cover the distance of one millimeter on the scale, and since the screw readings increase when the threads are moved in a direction opposite to that of increasing numbers on the scale, it is evident, that, if it were not for runs, the readings on line 70 would be less than those on line 65 by exactly 10  $R$ . If that is not the case, then the correction to be added to any observed  $\frac{1}{2} m$  in order to reduce it to the case of no runs of the screw, is

$$-(\frac{1}{2}m) \frac{r}{5} \text{ millimeters,}$$

where

$$2r = \text{Read. on line 65} - \text{Read. on line 70} - 10R.$$

Thus  $2r$  is the total error of runs on ten revolutions; for each day of observation it is evidently equal numerically to the "Runs in mm." of TABLE II. For one millimeter the error will evidently be  $\frac{1}{2} \cdot 2r/5$ , the factor  $\frac{1}{2}$  reducing the quotient to mm. And since the correction to each  $\frac{1}{2} m$  must be proportional to

TABLE IV.—DIVISION ERRORS OF THE SCALE.

| Line. | Correction in<br>mm. | Line. | Correction in<br>mm. | Line. | Correction in<br>mm. |
|-------|----------------------|-------|----------------------|-------|----------------------|
| 0     | 0.0000               | 44    | +0.0029              | 88    | +0.0025              |
| 1     | +0.0011              | 45    | +0.0020              | 89    | +0.0026              |
| 2     | -0.0007              | 46    | +0.0021              | 90    | +0.0018              |
| 3     | -0.0001              | 47    | +0.0006              | 91    | +0.0027              |
| 4     | +0.0002              | 48    | +0.0013              | 92    | +0.0025              |
| 5     | -0.0004              | 49    | +0.0015              | 93    | +0.0026              |
| 6     | +0.0001              | 50    | +0.0007              | 94    | +0.0026              |
| 7     | -0.0013              | 51    | +0.0018              | 95    | +0.0026              |
| 8     | -0.0008              | 52    | +0.0030              | 96    | +0.0019              |
| 9     | -0.0009              | 53    | +0.0024              | 97    | +0.0008              |
| 10    | -0.0001              | 54    | +0.0032              | 98    | +0.0014              |
| 11    | +0.0014              | 55    | +0.0028              | 99    | +0.0004              |
| 12    | +0.0006              | 56    | +0.0030              | 100   | +0.0019              |
| 13    | +0.0014              | 57    | +0.0034              | 101   | +0.0004              |
| 14    | +0.0016              | 58    | +0.0038              | 102   | -0.0005              |
| 15    | +0.0015              | 59    | +0.0034              | 103   | +0.0002              |
| 16    | +0.0009              | 60    | +0.0034              | 104   | +0.0014              |
| 17    | +0.0008              | 61    | +0.0038              | 105   | +0.0009              |
| 18    | +0.0012              | 62    | +0.0044              | 106   | +0.0012              |
| 19    | +0.0012              | 63    | +0.0058              | 107   | +0.0002              |
| 20    | +0.0007              | 64    | +0.0050              | 108   | +0.0012              |
| 21    | +0.0015              | 65    | +0.0053              | 109   | .0000                |
| 22    | +0.0016              | 66    | +0.0059              | 110   | -0.0002              |
| 23    | +0.0014              | 67    | +0.0050              | 111   | +0.0002              |
| 24    | +0.0012              | 68    | +0.0052              | 112   | -0.0006              |
| 25    | +0.0007              | 69    | +0.0057              | 113   | -0.0013              |
| 26    | +0.0026              | 70    | +0.0054              | 114   | +0.0005              |
| 27    | +0.0033              | 71    | +0.0056              | 115   | -0.0003              |
| 28    | +0.0026              | 72    | +0.0047              | 116   | .0000                |
| 29    | +0.0020              | 73    | +0.0046              | 117   | +0.0020              |
| 30    | +0.0035              | 74    | +0.0047              | 118   | +0.0022              |
| 31    | +0.0030              | 75    | +0.0037              | 119   | +0.0026              |
| 32    | +0.0022              | 76    | +0.0052              | 120   | +0.0021              |
| 33    | +0.0024              | 77    | +0.0045              | 121   | +0.0014              |
| 34    | +0.0013              | 78    | +0.0041              | 122   | +0.0024              |
| 35    | +0.0032              | 79    | +0.0040              | 123   | +0.0015              |
| 36    | +0.0024              | 80    | +0.0033              | 124   | +0.0024              |
| 37    | +0.0025              | 81    | +0.0043              | 125   | +0.0012              |
| 38    | +0.0016              | 82    | +0.0029              | 126   | +0.0018              |
| 39    | +0.0025              | 83    | +0.0050              | 127   | +0.0014              |
| 40    | +0.0033              | 84    | +0.0034              | 128   | +0.0005              |
| 41    | +0.0020              | 85    | +0.0021              | 129   | +0.0015              |
| 42    | +0.0025              | 86    | +0.0014              | 130   | .0000                |
| 43    | +0.0024              | 87    | +0.0026              |       |                      |



that quantity, the above formula follows at once. Tables with the argument  $\frac{1}{2}m$  may evidently be constructed giving the corrections corresponding to any value of  $2r$ .

Before proceeding to do so, however, let us consider the errors of the screw. These are of two kinds, periodic and non-periodic. The former were eliminated during the measurement by always setting the screw to a certain reading (usually  $9R$ ) when pointing at a star during the first half of the day's work, and then, upon reversing the operation, setting it always at a reading differing from the former by  $0.5R$ . Thus each star was read with the screw in both positions. In order to obviate the effects of non-uniformity of pitch, certain corrections must be applied, however. Investigation showed these to be :

| Reading of Micrometer Head. | Corrections in Millimeters. |                   |
|-----------------------------|-----------------------------|-------------------|
|                             | Vertical Screw.             | Horizontal Screw. |
| $5R$                        | 0.0000                      | 0.0000            |
| 6                           | +0.0004                     | +0.0005           |
| 7                           | +0.0004                     | +0.0002           |
| 8                           | -0.0002                     | -0.0003           |
| 9                           | -0.0007                     | -0.0012           |
| 10                          | -0.0014                     | -0.0017           |
| 11                          | -0.0020                     | -0.0022           |
| 12                          | -0.0024                     | -0.0021           |
| 13                          | -0.0023                     | -0.0022           |
| 14                          | -0.0013                     | -0.0014           |
| 15                          | 0.0000                      | 0.0000            |

The above quantities are in mm. and must be added to the readings. The vertical screw was used for one plate only, No. II; the following discussion applies to it as well as to the horizontal screw, *mutatis mutandis*.

It will be seen that between  $9R$  and  $11R$  the increase in the correction is proportionate to the distance from  $9R$ . Hence if we start our measures of any star with the original setting of the micrometer head at  $9R$ , then the increase in the correction will be proportionate to  $\frac{1}{2}m$ , remembering that the maximum value  $\frac{1}{2}m$  can have is 1.0, which corresponds to  $2R$ . This was always done except in certain cases to be mentioned later. As the coördinates are the difference between the readings on the

stars and the readings on the central taken on the same day, we may, without affecting the final results, subtract a constant from the screw correction. Taking, then, the zero point at  $9R$ , and as our argument tenths of millimeters (or fifths of a revolution) beyond  $9R$ , we get the following table for correcting the readings of the horizontal screw :

| Reading of Head. | Corresp. $\frac{1}{2}m$ . | Corresp. Correction. |
|------------------|---------------------------|----------------------|
| 9.0              | 0.0                       | 0.0000               |
| 9.2              | 0.1                       | —0.0001              |
| 9.4              | 0.2                       | —0.0002              |
| 9.6              | 0.3                       | —0.0003              |
| 9.8              | 0.4                       | —0.0004              |
| 10.0             | 0.5                       | —0.0005              |
| 10.2             | 0.6                       | —0.0006              |
| 10.4             | 0.7                       | —0.0007              |
| 10.6             | 0.8                       | —0.0008              |
| 10.8             | 0.9                       | —0.0009              |
| 11.0             | 1.0                       | —0.0010              |

During the second half of a day's work, the initial setting on the star was usually  $9.5R$ . As a result, the readings on the scale sometimes fell beyond  $11R$ . For such cases the above table will no longer apply as it stands, for the correction beyond  $11R$  does not bear the same proportion to  $\frac{1}{2}m$  as holds below that point. We may, however, construct a table similar to the preceding, but differing in the last figures. For, all the stars being again measured beginning always at the same point on the screw, we may, as before, subtract a constant from the screw corrections. We obtain thus the table :

| Reading of Head. | Corresponding $\frac{1}{2}m$ . | Corresponding Correction. |
|------------------|--------------------------------|---------------------------|
| 9.5              | 0.0                            | —0.0000                   |
| 9.7              | 0.1                            | —0.0001                   |
| 9.9              | 0.2                            | —0.0002                   |
| 10.1             | 0.3                            | —0.0003                   |
| 10.3             | 0.4                            | —0.0004                   |
| 10.5             | 0.5                            | —0.0005                   |
| 10.7             | 0.6                            | —0.0006                   |
| 10.9             | 0.7                            | —0.0007                   |
| 11.1             | 0.8                            | —0.00074                  |
| 11.3             | 0.9                            | —0.00072                  |
| 11.5             | 1.0                            | —0.00070                  |

One plate was measured, beginning with  $8.7R$  during the first half, and  $9.2R$  during the second half of each morning's work. This required the construction of a third table. The method was entirely similar to the above, so that I need not enter on it here.

In the foregoing it has been shown that the screw correction may be put in a form to be directly proportionate to  $\frac{1}{2}m$ . But we have seen previously, that, from the nature of things, the correction for runs is proportionate to the same quantity. We can therefore construct a table with the argument  $\frac{1}{2}m$ , which will give at once the combined effect of both corrections. For example, let us consider the case of Dec. 14th, 1897. From Table II we find that  $2r$  on that date was  $-0.0069$  mm., *i. e.*, the means of the four differences

$$\text{Read. on } 65 - \text{Read. on } 70 - 10R$$

was  $-0.0069$  mm. The screw therefore *registers* less than the true distance, and a certain quantity must be added to each  $\frac{1}{2}m$ . By the general formula this quantity is

$$(\frac{1}{2}m) \times 0.0138/10 \text{ millimeters.}$$

Giving  $\frac{1}{2}m$  the values 0.1, 0.2 . . . 1.0, and combining with the corresponding screw corrections, we get the table

| $\frac{1}{2}m$ . | Beginning at 9.0 | Beginning at 9.5 |
|------------------|------------------|------------------|
| 0.0              | + 0.00000        | + 0.00000        |
| 0.1              | .00004           | .00004           |
| 0.2              | .00008           | .00008           |
| 0.3              | .00011           | .00011           |
| 0.4              | .00015           | .00015           |
| 0.5              | .00019           | .00019           |
| 0.6              | .00023           | .00023           |
| 0.7              | .00027           | .00027           |
| 0.8              | .00030           | .00036           |
| 0.9              | .00034           | .00052           |
| 1.0              | .00038           | .00068           |

Tables like the specimen were constructed for each observed value of the runs. The columns headed "Beginning at 9.0" and "Beginning at 9.5" give the corrections in mm., to be applied

to the measured  $\frac{1}{2} m$ 's. They refer respectively to the first and to the second half of the morning's work. One point regarding the use of these tables deserves mention: It sometimes happens that the reading on the scale corresponding to one image of a star is less, and that corresponding to the other image is greater than  $11R$ . In such cases the correction must be found from the table separately for each reading, and then the mean of the two taken. This is evident if we remember the way in which  $\frac{1}{2}m$  is obtained.

**Measured Coördinates and Rotation Errors.**—Having applied the corrections described above, we are in position to obtain the measured coördinates. These are the differences of the readings on a star and the readings on the central star, *i. e.*, star No. 14. As the  $x$  is to be positive when the star has a greater right ascension, and the  $y$  is to be positive when it has a greater declination (algebraically) than the central, we must apply the following rule: Subtract the position of the star from that of the central for  $x$  *direct*, and subtract the central from the star for  $y$  *direct*. For the opposite positions of the plate these operations must, of course, be reversed. The reasons for this rule are plain, when we remember that the numbers on the scale increase towards the right.

The coördinates thus obtained are not yet free from error, however. For it is evident that, unless the plate were always rotated exactly  $90^\circ$  from its previous position, the axes of reference would not be rectangular. This was, however, found to be impossible of accomplishment. The best that could be done was to turn the plate approximately  $90^\circ$ , and then to measure exactly the angle through which it had been rotated. In order to obtain formulæ to reduce the measured coördinates to what they should have been, let us call

$x', y'$  the coördinates referred to the central star as measured;

$x, y$  the same coördinates as they should be;

$OX' OY'$  the position the axes actually had on the plate;

$OX, OY$  the position they should have had;

$\theta$  the angle  $XOX'$ , positive if the plate must be turned counter-clockwise in order to make  $OX$  and  $OX'$  coincide. Then the positive  $OX'$  will fall between positive  $OX$  and  $OY$ , for, *on the plate*, positive coördinates correspond to the usual position of the axes, *i. e.*, positive  $x$  to the right, and positive  $y$  up, when the trail is left (corresponding to  $x$  reversed).

Let also  $x'_0, y'_0; x_0, y_0$  be the coördinates of the central star referred to the center of rotation,  $o$ , corresponding to the actual and to the corrected position of the plate respectively.

Then by the usual formulæ for the transformation of coördinates, we have

$$\begin{aligned}x_0 + x &= (x'_0 + x') \cos \theta - (y'_0 + y') \sin \theta \\y_0 + y &= (x'_0 + x') \sin \theta + (y'_0 + y') \cos \theta\end{aligned}$$

or expanding and remembering that

$$\begin{aligned}x_0 &= x'_0 \cos \theta - y'_0 \sin \theta \\y_0 &= x'_0 \sin \theta + y'_0 \cos \theta\end{aligned}$$

and that  $\theta$  is very small, we find

$$\begin{aligned}x - x' &= y', \theta'' \sin 1'' \\y - y' &= x', \theta'' \sin 1''\end{aligned}$$

*i. e.*, from the measured  $x'$  we must subtract  $y', \theta'' \sin 1''$  and to the measured  $y'$  we must add  $x', \theta'' \sin 1''$  in order to obtain the correct coördinates.<sup>1</sup> It will be seen that these formulæ take account of the fact that the center of rotation of the plate does not coincide in position with the origin of coördinates.

To determine what sign to give  $\theta''$  in any special case, we need but remember that in the Repsold measuring machine an increase in angle corresponds to positive (counter-clockwise) rotation of the plate. Hence if we let

$Q$  = the seconds of the circle reading to which all the positions are to be reduced ;

<sup>1</sup> See in this connection Harold Jacoby, "Permanence of the Rutherford Photographic Plates," *Annals New York Academy of Sciences*, Vol. IX, p. 267, where the same formulæ are given.

$Q'$  = the seconds actually read on the circles at any given date, then will the equation

$$Q - Q' = \theta''$$

give  $\theta''$  with the sign with which it is to be used in the formulæ.

Tables can, of course, be constructed for any value of  $\theta''$ , having as argument distances in millimeters. This has been done and by their aid the measured coördinates have been reduced to the position of rectangular axes. The values of  $Q$  used were as follows ( $Q$  need not, of course, be any one of the readings; it is best taken so as to make the corrections as small as possible).

|              |                   |
|--------------|-------------------|
| Plate I..... | $Q = 60''$        |
| II.....      | $43''$            |
| III.....     | $23''$            |
| IV.....      | $40''\frac{1}{2}$ |
| V.....       | $58''\frac{1}{2}$ |
| VI.....      | $9''\frac{3}{4}$  |
| VII.....     | $20''\frac{3}{4}$ |
| VIII.....    | $26''$            |
| IX.....      | $5''\frac{1}{2}$  |
| X.....       | $29''\frac{3}{4}$ |
| XI.....      | $44''\frac{1}{4}$ |
| XII.....     | $8''$             |
| XIII.....    | $16''\frac{1}{4}$ |
| XIV.....     | $36''\frac{1}{4}$ |

**Scale-Value Corrections, Projection Errors, and Deviation of the Cylinder from Straightness.**—None of these have any appreciable effect. The first is due to the fact that the scale is made of German silver, while the plate is glass. Changes in temperature might, therefore, give rise to unequal expansion, and hence to a change in the scale-value. Dr. Schlesinger<sup>1</sup> in 1897 investigated this question, and his results show that in no case could this change affect my results by as much as  $0''.04$ . I have therefore felt justified in neglecting this error altogether.

<sup>1</sup> See his "Præsepe" pp. 220–223.



The second category, projection errors, have been eliminated entirely in the case of the Repsold machine in use for the present research by an improved guiding way with which it was equipped in 1896.

As regards the deviation of the cylinder from straightness, an investigation made under Professor Jacoby's<sup>1</sup> direction shows that no appreciable error is introduced thereby, the greatest range of variation not exceeding  $0''.04$ . I have therefore neglected this correction.

In TABLE V are recorded the final corrected coördinates obtained from the measures of TABLE III. The process of computing them is very simple: To the number of the line add the mean of the two corresponding  $\frac{1}{2}m$ 's corrected for runs and division errors. In case two lines are used, substitute for the line of above the mean of the lines. The result is the mean position of the star with respect to the scale for each of the four positions of the plate. Then calculate the measured coördinates, as previously explained, by comparison of these four quantities with the corresponding quantities for the central star, obtained in the same manner. Apply thereto the rotation corrections, having care for the sign, and the result will be the quantities set down in TABLE V. No further explanation of the terms there used is necessary; it may be mentioned, however, that, as before, unity in the fourth place of decimals corresponds to about  $0''.005$ .

<sup>1</sup> "Permanence of the Rutherford Photographic Plates," *Annals New York Academy of Sciences*, Vol. IX, p. 207.

TABLE V: CORRECTED COÖRDINATES.—PLATE I.

| Star. | <i>x</i> |        |          | <i>y</i> |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 4     | —33.4486 | .4522  | —33.4504 | +10.6314 | .6347  | +10.6330 |
| 5     | —32.9343 | .9338  | —32.9340 | +52.9854 | .9858  | +52.9856 |
| 6     | —26.7422 | .7442  | —26.7432 | — 5.3955 | .3940  | — 5.3948 |
| 7     | —24.7756 | .7789  | —24.7772 | + 5.5318 | .5353  | + 5.5336 |
| 8     | —21.8240 | .8270  | —21.8255 | — 8.4788 | .4781  | — 8.4784 |
| 9     | —21.8558 | .8547  | —21.8552 | —55.7458 | .7367  | —55.7412 |
| 10    | —16.3928 | .3916  | —16.3922 | —57.7500 | .7487  | —57.7494 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | + 0.2751 | .2735  | + 0.2743 | — 1.2018 | .1972  | — 1.1995 |
| 21    | +23.7752 | .7740  | +23.7746 | + 0.3586 | .3601  | + 0.3594 |
| 22    | +27.5780 | .5766  | +27.5773 | +17.1978 | .1985  | +17.1982 |
| 23    | +29.7712 | .7702  | +29.7707 | —17.9134 | .9107  | —17.9120 |
| 24    | +38.8579 | .8559  | +38.8569 | —19.3756 | .3737  | —19.3746 |

PLATE II.

| Star. | <i>x</i> |        |          | <i>y</i> |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | —58.2719 | .2778  | —58.2748 | +23.5483 | .5442  | +23.5462 |
| 2     | —53.0671 | .0645  | —53.0658 | +11.2654 | .2644  | +11.2649 |
| 4     | —33.4508 | .4523  | —33.4516 | +10.6330 | .6326  | +10.6328 |
| 5     | —32.9292 | .9312  | —32.9302 | +52.9774 | .9766  | +52.9770 |
| 6     | —26.7470 | .7398  | —26.7434 | — 5.3878 | .3947  | — 5.3912 |
| 7     | —24.7784 | .7777  | —24.7780 | + 5.5358 | .5301  | + 5.5330 |
| 8     | —21.8238 | .8238  | —21.8238 | — 8.4796 | .4852  | — 8.4824 |
| 9     | —21.8519 | .8518  | —21.8518 | —55.7386 | .7399  | —55.7392 |
| 10    | —16.3881 | .3884  | —16.3882 | —57.7504 | .7524  | —57.7514 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | + 0.2804 | .2790  | + 0.2797 | — 1.1986 | .2021  | — 1.2004 |
| 18    | + 9.7201 | .7263  | + 9.7232 | + 0.3576 | .3514  | + 0.3545 |
| 19    | +15.1144 | .1175  | +15.1160 | +48.9410 | .9358  | +48.9384 |
| 21    | +23.7754 | .7766  | +23.7760 | + 0.3618 | .3574  | + 0.3596 |
| 22    | +27.5754 | .5773  | +27.5764 | +17.2022 | .1990  | +17.2006 |
| 23    | +29.7710 | .7716  | +29.7713 | —17.9077 | .9147  | —17.9112 |
| 24    | +38.8609 | .8567  | +38.8588 | —19.3713 | .3775  | —19.3744 |

TABLE V. (*Continued.*)—PLATE III.

| Star. | <i>x</i> |        |          | <i>y</i> |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | —58.2620 | .2648  | —58.2634 | +25.5445 | .5380  | +23.5412 |
| 2     | —53.0662 | .0700  | —53.0681 | +11.2665 | .2622  | +11.2644 |
| 4     | —33.4544 | .4530  | —33.4537 | +10.6342 | .6276  | +10.6309 |
| 5     | —32.9304 | .9296  | —32.9300 | +52.9755 | .9745  | +52.9750 |
| 6     | —26.7541 | .7469  | —26.7505 | —5.3911  | .3963  | —5.3937  |
| 7     | —24.7809 | .7782  | —24.7796 | +5.5359  | .5323  | +5.5341  |
| 8     | —21.8324 | .8260  | —21.8292 | —8.4786  | .4822  | —8.4804  |
| 9     | —21.8538 | .8461  | —21.8500 | —55.7366 | .7364  | —55.7365 |
| 10    | —16.3894 | .3853  | —16.3874 | —57.7463 | .7476  | —57.7470 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | +0.2750  | .2778  | +0.2764  | —1.1972  | .1977  | —1.1974  |
| 21    | +23.7722 | .7748  | +23.7735 | +0.3642  | .3636  | +0.3639  |
| 22    | +27.5723 | .5754  | +27.5738 | +17.2067 | .2034  | +17.2050 |
| 23    | +29.7719 | .7714  | +29.7716 | —17.9065 | .9081  | —17.9073 |
| 24    | +38.8564 | .8581  | +38.8572 | —19.3675 | .3695  | —19.3685 |

PLATE IV.

| Star. | <i>x</i> |        |          | <i>y</i> |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | —58.2560 | .2624  | —58.2592 | +23.5562 | .5520  | +23.5541 |
| 2     | —53.0578 | .0647  | —53.0612 | +11.2722 | .2695  | +11.2708 |
| 4     | —33.4568 | .4609  | —33.4588 | +10.6384 | .6371  | +10.6378 |
| 5     | —32.9293 | .9307  | —32.9300 | +52.9750 | .9742  | +52.9746 |
| 6     | —26.7400 | .7466  | —26.7433 | —5.3934  | .3934  | —5.3934  |
| 7     | —24.7681 | .7752  | —24.7716 | +5.5320  | .5330  | +5.5325  |
| 8     | —21.8154 | .8214  | —21.8184 | —8.4838  | .4825  | —8.4832  |
| 9     | —21.8650 | .8683  | —21.8666 | —55.7318 | .7314  | —55.7316 |
| 10    | —16.3799 | .3819  | —16.3809 | —57.7526 | .7526  | —57.7526 |
| 11    | —11.6300 | .6375  | —11.6338 | +51.8848 | .8879  | +51.8864 |
| 12    | —10.4174 | .4291  | —10.4232 | +47.8555 | .8585  | +47.8570 |
| 13    | —8.3504  | .3548  | —8.3526  | —10.9044 | .9059  | —10.9052 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | +0.2873  | .2791  | +0.2832  | —1.1969  | .1957  | —1.1963  |
| 17    | +2.8632  | .8579  | +2.8606  | —2.6923  | .6944  | —2.6934  |
| 18    | +9.7326  | .7281  | +9.7304  | +0.3565  | .3559  | +0.3562  |
| 21    | +23.7834 | .7796  | +23.7815 | +0.3636  | .3618  | +0.3627  |
| 22    | +27.5772 | .5736  | +27.5754 | +17.2032 | .2006  | +17.2019 |
| 23    | +29.7781 | .7763  | +29.7772 | —17.9082 | .9079  | —17.9080 |
| 24    | +38.8654 | .8599  | +38.8626 | —19.3742 | .3747  | —19.3744 |

TABLE V. (*Continued.*)—PLATE V.

| Star. | $x$      |        |          | $y$      |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | —58.2650 | .2707  | —58.2678 | +23.5358 | .5303  | +23.5330 |
| 2     | —53.0626 | .0662  | —53.0644 | +11.2525 | .2497  | +11.2511 |
| 4     | —33.4616 | .4650  | —33.4633 | +10.6267 | .6258  | +10.6262 |
| 5     | —32.9462 | .9504  | —32.9483 | +52.9591 | .9589  | +52.9590 |
| 6     | —26.7382 | .7444  | —26.7413 | —5.4030  | .4030  | —5.4030  |
| 7     | —24.7719 | .7780  | —24.7750 | +5.5258  | .5274  | +5.5266  |
| 8     | —21.8204 | .8223  | —21.8214 | —8.4910  | .4940  | —8.4925  |
| 9     | —21.8487 | .8525  | —21.8506 | —55.7340 | .7348  | —55.7344 |
| 10    | —16.3637 | .3685  | —16.3658 | —57.7569 | .7575  | —57.7572 |
| 13    | —8.3530  | .3578  | —8.3554  | —10.9114 | .9105  | —10.9110 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | +0.2886  | .2818  | +0.2852  | —1.1988  | .1988  | —1.1988  |
| 18    | +9.7282  | .7244  | +9.7263  | +0.3561  | .3549  | +0.3555  |
| 19    | +15.1028 | .0974  | +15.1001 | +48.9430 | .9453  | +48.9442 |
| 21    | +23.7781 | .7737  | +23.7759 | +0.3662  | .3684  | +0.3673  |
| 22    | +27.5677 | .5650  | +27.5664 | +17.2096 | .2033  | +17.2064 |
| 23    | +29.7851 | .7794  | +29.7822 | —17.8990 | .8979  | —17.8984 |
| 24    | +38.8670 | .8616  | +38.8643 | —19.3621 | .3586  | —19.3604 |

PLATE VI.

| Star. | $x$      |        |          | $y$      |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | —58.2580 | .2618  | —58.2599 | +23.5561 | .5588  | +23.5574 |
| 2     | —53.0621 | .0613  | —53.0617 | +11.2721 | .2736  | +11.2728 |
| 3     | —50.0673 | .0729  | —50.0701 | —53.2676 | .2650  | —53.2663 |
| 4     | —33.4605 | .4633  | —33.4619 | +10.6406 | .6420  | +10.6413 |
| 5     | —32.9322 | .9349  | —32.9336 | +52.9704 | .9730  | +52.9717 |
| 6     | —26.7438 | .7493  | —26.7466 | —5.3929  | .3892  | —5.3910  |
| 7     | —24.7752 | .7780  | —24.7766 | +5.5377  | .5386  | +5.5382  |
| 8     | —21.8209 | .8245  | —21.8227 | —8.4811  | .4792  | —8.4802  |
| 9     | —21.8743 | .8745  | —21.8744 | —55.7257 | .7217  | —55.7237 |
| 10    | —16.3890 | .3880  | —16.3885 | —57.7475 | .7452  | —57.7464 |
| 11    | —11.6369 | .6420  | —11.6394 | +51.8649 | .8696  | +51.8672 |
| 12    | —10.4297 | .4324  | —10.4310 | +47.8528 | .8597  | +47.8562 |
| 13    | —8.3571  | .3636  | —8.3604  | —10.9046 | .9033  | —10.9040 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | +0.2826  | .2762  | +0.2794  | —1.1996  | .1968  | —1.1982  |
| 16    | +1.1405  | .1328  | +1.1366  | +52.7970 | .8062  | +52.8016 |
| 18    | +9.7236  | .7226  | +9.7231  | +0.3517  | .3550  | +0.3534  |
| 19    | +15.1181 | .1156  | +15.1168 | +48.9331 | .9424  | +48.9378 |
| 21    | +23.7693 | .7665  | +23.7679 | +0.3593  | .3604  | +0.3598  |
| 22    | +27.5703 | .5701  | +27.5702 | +17.2003 | .1994  | +17.1998 |
| 23    | +29.7688 | .7652  | +29.7670 | —17.9120 | .9106  | —17.9113 |
| 24    | +38.8544 | .8484  | +38.8514 | —19.3774 | .3776  | —19.3775 |

TABLE V. (*Continued.*)—PLATE VII.

| Star. | $x$      |        |          | $y$      |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | —58.2601 | .2651  | —58.2626 | +23.5588 | .5526  | +23.5557 |
| 2     | —53.0655 | .0687  | —53.0671 | +11.2748 | .2747  | +11.2748 |
| 4     | —33.4650 | .4662  | —33.4656 | +10.6410 | .6428  | +10.6419 |
| 5     | —32.9299 | .9332  | —32.9316 | +52.9760 | .9726  | +52.9743 |
| 6     | —26.7556 | .7570  | —26.7563 | — 5.3908 | .3920  | — 5.3914 |
| 7     | —24.7795 | .7817  | —24.7806 | + 5.5342 | .5370  | + 5.5356 |
| 8     | —21.8218 | .8267  | —21.8242 | — 8.4808 | .4818  | — 8.4813 |
| 9     | —21.8783 | .8788  | —21.8786 | —55.7250 | .7232  | —55.7241 |
| 10    | —16.3971 | .3976  | —16.3974 | —57.7537 | .7519  | —57.7528 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | + 0.2794 | .2742  | + 0.2768 | — 1.2020 | .2012  | — 1.2016 |
| 18    | + 9.7144 | .7113  | + 9.7128 | + 0.3494 | .3496  | + 0.3495 |
| 21    | +23.7738 | .7674  | +23.7706 | + 0.3568 | .3545  | + 0.3556 |
| 22    | +27.5792 | .5780  | +27.5786 | +17.2016 | .1974  | +17.1995 |
| 23    | +29.7699 | .7658  | +29.7678 | —17.9171 | .9181  | —17.9176 |
| 24    | +38.8525 | .8476  | +38.8500 | —19.3797 | .3778  | —19.3788 |

PLATE VIII.

| Star. | $x$      |        |          | $y$      |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | —58.2581 | .2575  | —58.2578 | +23.5670 | .5632  | +23.5651 |
| 2     | —53.0606 | .0615  | —53.0610 | +11.2769 | .2776  | +11.2772 |
| 4     | —33.4612 | .4587  | —33.4600 | +10.6426 | .6452  | +10.6439 |
| 5     | —32.9260 | .9246  | —32.9253 | +52.9780 | .9778  | +52.9779 |
| 6     | —26.7405 | .7376  | —26.7390 | — 5.3864 | .3878  | — 5.3871 |
| 7     | —24.7710 | .7703  | —24.7706 | + 5.5386 | .5385  | + 5.5386 |
| 8     | —21.8209 | .8191  | —21.8200 | — 8.4806 | .4798  | — 8.4802 |
| 9     | —21.8729 | .8683  | —21.8706 | —55.7246 | .7226  | —55.7236 |
| 10    | —16.3856 | .3847  | —16.3852 | —57.7510 | .7526  | —57.7518 |
| 11    | —11.6298 | .6259  | —11.6278 | +51.8749 | .8754  | +51.8752 |
| 12    | —10.4207 | .4170  | —10.4188 | +47.8600 | .8604  | +47.8602 |
| 13    | — 8.3557 | .3530  | — 8.3544 | —10.9043 | .9070  | —10.9056 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | + 0.2870 | .2872  | + 0.2871 | — 1.1968 | .1988  | — 1.1978 |
| 16    | + 1.1388 | .1420  | + 1.1404 | +52.8096 | .8088  | +52.8092 |
| 17    | + 2.8614 | .8654  | + 2.8634 | — 2.6900 | .6924  | — 2.6912 |
| 18    | + 9.7342 | .7326  | + 9.7334 | + 0.3557 | .3564  | + 0.3560 |
| 19    | +15.1191 | .1238  | +15.1214 | +48.9421 | .9451  | +48.9436 |
| 20    | +18.1893 | .1945  | +18.1919 | +51.4121 | .4146  | +51.4134 |
| 21    | +23.7749 | .7760  | +23.7754 | + 0.3616 | .3592  | + 0.3604 |
| 22    | +27.5738 | .5757  | +27.5748 | +17.1986 | .1958  | +17.1972 |
| 23    | +29.7734 | .7743  | +29.7738 | —17.9118 | .9150  | —17.9134 |
| 24    | +38.8538 | .8543  | +38.8540 | —19.3720 | .3780  | —19.3750 |

TABLE V. (*Continued.*)—PLATE IX.

| Star. | $x$      |        |          | $y$      |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | -58.2551 | .2582  | -58.2566 | +23.5698 | .5634  | +23.5666 |
| 2     | -53.0613 | .0698  | -53.0656 | +11.2819 | .2823  | +11.2821 |
| 4     | -33.4606 | .4641  | -33.4624 | +10.6450 | .6460  | +10.6455 |
| 5     | -32.9182 | .9217  | -32.9200 | +52.9774 | .9768  | +52.9771 |
| 7     | -24.7786 | .7778  | -24.7782 | +5.5375  | .5343  | +5.5359  |
| 8     | -21.8298 | .8329  | -21.8314 | -8.4781  | .4811  | -8.4796  |
| 9     | -21.8934 | .8956  | -21.8945 | -55.7175 | .7174  | -55.7174 |
| 10    | -16.4058 | .4102  | -16.4080 | -57.7476 | .7446  | -57.7461 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | +0.2803  | .2794  | +0.2798  | -1.2007  | .2009  | -1.2008  |
| 21    | +23.7728 | .7681  | +23.7704 | +0.3512  | .3523  | +0.3518  |
| 22    | +27.5804 | .5754  | +27.5779 | +17.1920 | .1910  | +17.1915 |
| 23    | +29.7660 | .7615  | +29.7648 | -17.9179 | .9176  | -17.9178 |
| 24    | +38.8439 | .8396  | +38.8418 | -19.3814 | .3847  | -19.3830 |

PLATE X.

| Star. | $x$      |        |          | $y$      |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | -58.2564 | .2625  | -58.2594 | +23.5601 | .5552  | +23.5576 |
| 2     | -53.0639 | .0642  | -53.0640 | +11.2759 | .2752  | +11.2756 |
| 4     | -33.4631 | .4610  | -33.4620 | +10.6417 | .6424  | +10.6420 |
| 5     | -32.9253 | .9203  | -32.9228 | +52.9682 | .9704  | +52.9693 |
| 6     | -26.7460 | .7428  | -26.7444 | -5.3868  | .3884  | -5.3876  |
| 7     | -24.7753 | .7745  | -24.7749 | +5.5351  | .5354  | +5.5352  |
| 8     | -21.8284 | .8262  | -21.8273 | -8.4829  | .4840  | -8.4834  |
| 9     | -21.8890 | .8859  | -21.8874 | -55.7277 | .7219  | -55.7248 |
| 10    | -16.3983 | .3957  | -16.3970 | -57.7508 | .7466  | -57.7487 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | +0.2781  | .2789  | +0.2785  | -1.2034  | .2018  | -1.2026  |
| 18    | +9.7222  | .7286  | +9.7254  | +0.3488  | .3470  | +0.3479  |
| 21    | +23.7712 | .7742  | +23.7727 | +0.3565  | .3560  | +0.3562  |
| 22    | +27.5761 | .5817  | +27.5789 | +17.1948 | .1934  | +17.1941 |
| 23    | +29.7670 | .7706  | +29.7688 | -17.9144 | .9137  | -17.9140 |
| 24    | +38.8486 | .8532  | +38.8509 | -19.3782 | .3807  | -19.3794 |



TABLE V. (*Continued.*)—PLATE XI.

| Star. | $x$      |        |          | $y$      |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | —58.2564 | .2592  | —58.2578 | +23.5596 | .5562  | +23.5579 |
| 2     | —53.0621 | .0660  | —53.0640 | +11.2741 | .2711  | +11.2726 |
| 4     | —33.4594 | .4597  | —33.4596 | +10.6401 | .6392  | +10.6396 |
| 5     | —32.9226 | .9234  | —32.9230 | +52.9687 | .9684  | +52.9686 |
| 6     | —26.7522 | .7479  | —26.7500 | — 5.3871 | .3895  | — 5.3883 |
| 7     | —24.7722 | .7697  | —24.7710 | + 5.5390 | .5372  | + 5.5381 |
| 8     | —21.8256 | .8179  | —21.8218 | — 8.4805 | .4841  | — 8.4823 |
| 9     | —21.8870 | .8816  | —21.8843 | —55.7231 | .7197  | —55.7214 |
| 10    | —16.3952 | .3924  | —16.3938 | —57.7490 | .7449  | —57.7470 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | + 0.2768 | .2814  | + 0.2791 | — 1.1956 | .1970  | — 1.1963 |
| 18    | + 9.7216 | .7226  | + 9.7221 | + 0.3549 | .3513  | + 0.3531 |
| 21    | +23.7726 | .7726  | +23.7726 | + 0.3580 | .3544  | + 0.3562 |
| 22    | +27.5747 | .5749  | +27.5748 | +17.1969 | .1944  | +17.1956 |
| 23    | +29.7672 | .7668  | +29.7670 | —17.9136 | .9128  | —17.9132 |
| 24    | +38.8473 | .8506  | +38.8490 | —19.3756 | .3799  | —19.3778 |

PLATE XII.

| Star. | $x$      |        |          | $y$      |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | —58.2619 | .2679  | —58.2649 | +23.5591 | .5483  | +23.5537 |
| 2     | —53.0571 | .0612  | —53.0592 | +11.2716 | .2644  | +11.2680 |
| 4     | —33.4623 | .4624  | —33.4624 | +10.6422 | .6340  | +10.6381 |
| 5     | —32.9350 | .9345  | —32.9348 | +52.9690 | .9676  | +52.9683 |
| 6     | —26.7476 | .7440  | —26.7458 | — 5.3892 | .3946  | — 5.3919 |
| 7     | —24.7767 | .7716  | —24.7742 | + 5.5382 | .5334  | + 5.5358 |
| 8     | —21.8276 | .8221  | —21.8248 | — 8.4786 | .4854  | — 8.4820 |
| 9     | —21.8805 | .8760  | —21.8782 | —55.7190 | .7243  | —55.7216 |
| 10    | —16.3883 | .3869  | —16.3876 | —57.7489 | .7512  | —57.7500 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | + 0.2779 | .2774  | + 0.2776 | — 1.1961 | .2012  | — 1.1986 |
| 18    | + 9.7161 | .7202  | + 9.7182 | + 0.3594 | .3524  | + 0.3559 |
| 21    | +23.7740 | .7724  | +23.7732 | + 0.3644 | .3568  | + 0.3606 |
| 22    | +27.5728 | .5718  | +27.5723 | +17.1999 | .1943  | +17.1971 |
| 23    | +29.7736 | .7704  | +29.7720 | —17.9049 | .9146  | —17.9098 |
| 24    | +38.8513 | .8524  | +38.8518 | —19.3698 | .3767  | —19.3732 |

TABLE V. (*Continued.*)—PLATE XIII.

| Star. | $x$      |        |          | $y$      |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | —58.2619 | .2583  | —58 2601 | +23.5697 | .5633  | +23.5665 |
| 2     | —53.0649 | .0642  | —53.0646 | +11.2839 | .2777  | +11.2808 |
| 4     | —33.4649 | .4610  | —33.4630 | +10.6485 | .6441  | +10.6463 |
| 5     | —32.9213 | .9176  | —32.9194 | +52.9749 | .9731  | +52.9740 |
| 6     | —26.7510 | .7398  | —26.7454 | —5.3814  | .3909  | —5.3862  |
| 7     | —24.7777 | .7690  | —24.7734 | +5.5398  | .5313  | +5.5356  |
| 8     | —21.8344 | .8285  | —21.8314 | —8.4738  | .4819  | —8.4778  |
| 9     | —21.9001 | .8930  | —21.8966 | —55.7162 | .7137  | —55.7150 |
| 10    | —16.4105 | .4004  | —16.4054 | —57.7415 | .7444  | —57.7430 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | +0.2760  | .2802  | +0.2781  | —1.1978  | .2032  | —1.2005  |
| 21    | +23.7697 | .7720  | +23.7708 | +0.3552  | .3505  | +0.3528  |
| 22    | +27.5772 | .5806  | +27.5789 | +17.1957 | .1904  | +17.1930 |
| 23    | +29.7630 | .7638  | +29.7634 | —17.9165 | .9203  | —17.9184 |
| 24    | +38.8422 | .8490  | +38.8456 | —19.3818 | .3866  | —19.3842 |

PLATE XIV.

| Star. | $x$      |        |          | $y$      |        |          |
|-------|----------|--------|----------|----------|--------|----------|
|       | Direct.  | Rev'd. | Mean.    | Direct.  | Rev'd. | Mean.    |
| 1     | —58.2545 | .2616  | —58.2580 | +23.5619 | .5552  | +23.5586 |
| 2     | —53.0607 | .0651  | —53.0629 | +11.2787 | .2722  | +11.2754 |
| 4     | —33.4612 | .4612  | —33.4612 | +10.6423 | .6374  | +10.6398 |
| 5     | —32.9212 | .9237  | —32.9224 | +52.9696 | .9671  | +52.9684 |
| 6     | —26.7502 | .7507  | —26.7504 | —5.3838  | .3923  | —5.3880  |
| 7     | —24.7776 | .7771  | —24.7774 | +5.5392  | .5299  | +5.5346  |
| 8     | —21.8272 | .8254  | —21.8263 | —8.4792  | .4873  | —8.4832  |
| 9     | —21.8933 | .8880  | —21.8906 | —55.7181 | .7237  | —55.7209 |
| 10    | —16.4015 | .3999  | —16.4007 | —57.7497 | .7480  | —57.7488 |
| 14    | 0.0000   | .0000  | 0.0000   | 0.0000   | .0000  | 0.0000   |
| 15    | +0.2740  | .2768  | +0.2754  | —1.1978  | .2043  | —1.2010  |
| 18    | +9.7200  | .7232  | +9.7216  | +0.3529  | .3454  | +0.3492  |
| 21    | +23.7728 | .7726  | +23.7727 | +0.3556  | .3497  | +0.3526  |
| 22    | +27.5779 | .5794  | +27.5786 | +17.1964 | .1896  | +17.1930 |
| 23    | +29.7691 | .7679  | +29.7685 | —17.9141 | .9213  | —17.9177 |
| 24    | +38.8475 | .8503  | +38.8489 | —19.3759 | .3852  | —19.3806 |

### III. Method of Reduction.

Having obtained in the manner explained in the preceding section the measured coördinates of the stars on the plates, we are in position to deduce from them the differences in right ascension and in declination to which they correspond. It is plain that certain corrections must be applied before this can be accomplished. In the first place, a photograph is a plane picture of the sky; hence we must introduce the "Transformation Corrections." Then the stars' positions are affected by refraction, precession, nutation and aberration, and the measures must be freed therefrom. We shall find, however, in the progress of the work, that before we can apply these corrections to the measured coördinates, we must reduce the latter into differences of right ascension and of declination (except for the corrections mentioned above) by means of certain constants to be discussed later. These are found by comparing the positions with respect to a given origin of certain well known stars on the plates with their measured coördinates, corrected for refraction, etc. These constants being known, we shall find that by means of simple formulæ the measured coördinates can be transformed into angular distances and at the same time freed from the effects of refraction and errors of orientation. Adding these distances to the known coördinates of the origin of measures on the plate, we obtain the celestial coördinates of the stars except for the transformation corrections. The latter are then applied to the means of all the observations on each star, and we have the final right ascensions and declinations.

Let us proceed to discuss these several steps.

**Transformation Corrections.**—An astronomical photograph may be regarded as a central projection on a plane of part of

the heavens. A certain quantity, known as the "Transformation Correction," must therefore be added to reduce any measured distance on the plate into the distance on the sky to which it corresponds. To find an expression for this correction, let us consider the spherical triangle whose vertices are the pole, the center of the plate, and any star on the plate. By center is meant the point at which a perpendicular on to its plane from the object glass cuts the plate. It is the point of tangency of the plate with the spherical image of the sky formed at the focus of the object glass. Now let

- $\alpha_0$  = the right ascension of the center, and
- $\alpha$  = the right ascension of any star;
- $\rho_0$  = the north polar distance of the center, and
- $\rho$  = that of the star;
- $\eta$  = the parallactic angle at the center, and
- $x$  = the angular distance from center to star;

then, by the usual formulæ [Chauvenet, Sph. Trig., Equ.'s (122), (123)]

$$\cos x = \frac{\cos (\rho_0 - q) \cos \rho}{\cos q} \quad (1)$$

$$\cot \eta = \frac{\sin (\rho_0 - q) \cot (a - \alpha_0)}{\sin q} \quad (2)$$

where

$$\tan q = \tan \rho \cos (a - \alpha_0). \quad (3)$$

Now consider a central projection of the figure onto a tangent plane at the center of the plate,  $O$ . Let  $OX$ ,  $OY$  be the axes,  $OY$  being the projection of the hour circle through the center  $O$ , and  $OX$  being perpendicular to  $OY$ . Let also  $S$  be the projected position of the star, and  $X$  and  $Y$  its rectangular coördinates on the plate expressed in seconds of arc of a great circle, the positive directions being the same as those of the "Measured Coördinates" (cf. p. 427). Then we shall have, taking the radius of the sphere as unity,

$$\begin{aligned} \angle \eta &= \angle YOS \\ X &= OS \sin YOS \\ Y &= OS \cos YOS. \end{aligned} \quad (99)$$

Also

$$OS = \tan x,$$

so that

$$\left. \begin{aligned} X &= \tan x \sin \eta \\ Y &= \tan x \cos \eta \end{aligned} \right\} \quad (4)$$

But from our spherical triangle

$$\sin x \sin \eta = \sin (a - a_0) \sin \phi. \quad (5)$$

Dividing (5) by (1), and remembering (4) we get

$$\tan x \sin \eta = X = \frac{\sin (a - a_0) \sin \phi \cos q}{\cos (\phi_0 - q) \cos \phi}. \quad (6)$$

Similarly multiplying (2) by (6) we get

$$\tan x \cos \eta = Y = \frac{\cos (a - a_0) \tan \phi \tan (\phi_0 - q)}{\tan q}. \quad (7)$$

These expressions may be easily transformed by the aid of (3). We obtain finally

$$\left. \begin{aligned} X &= \frac{\tan (a - a_0) \sin q}{\cos (\phi_0 - q)} \\ Y &= \tan (\phi_0 - q) \\ \tan q &= \tan \phi \cos (a - a_0) \end{aligned} \right\} \quad (8)^1$$

where

The formulæ (8) express rigorously the relation which holds between the true and the projected distances. They presuppose a knowledge of the scale-value, and of the position of the center, when the position of any other star may be found.

From these formulæ very convenient expressions can be obtained in the form of series, giving the transformation corrections to any desired degree of accuracy. They may be used with advantage to within  $15^\circ$  of the pole. Making the same assumptions as before with regard to the formulæ (8), let us write them :

$$X = \frac{\tan (a - a_0)}{\cos \phi_0 \cot q + \sin \phi_0} \quad (9)$$

$$\cot q = \frac{Y \tan \phi_0 + 1}{\tan \phi_0 - Y}. \quad (10)$$

<sup>1</sup> These are Turner's formulæ for transforming measured rectangular into celestial coördinates; cf. Observatory, Vol. 16, pp. 373 ff.

Substituting from (10) in (9) we get after slight reductions

$$X = \tan(a - a_0) \cos \rho_0 [\tan \rho_0 - Y],$$

or since

$$\cos \rho_0 = \sin \delta_0, \quad \sin \rho_0 = \cos \delta_0,$$

$$a - a_0 = \Delta a,$$

$$\tan \Delta a = \frac{X}{\cos \delta_0 - Y \sin \delta_0} = \frac{X \sec \delta_0}{1 - Y \tan \delta_0}. \quad (11)$$

Apply to this last expression the formula

$$\tan^{-1} u = u - \frac{1}{3} u^3 + \frac{1}{5} u^5 - \dots$$

and expand each term by division. To terms of the fourth order the resulting series will be

$$\Delta a = X \sec \delta_0 + A_1 (X \sec \delta_0) Y \quad \left. \begin{array}{l} A_1 = \tan \delta_0, \\ + A_2 (X \sec \delta_0) Y^2 \quad A_2 = \tan^2 \delta_0, \\ + A_3 (X \sec \delta_0)^3 \quad A_3 = -\frac{1}{3}, \\ + A_4 (X \sec \delta_0)^3 Y \quad A_4 = -\tan \delta_0, \\ + A_5 (X \sec \delta_0) Y^3 \quad A_5 = \tan^3 \delta_0. \end{array} \right\} \quad (12)^1$$

The process may easily be continued to any number of terms ; but for most cases even terms of the third order are almost inappreciable, and no accuracy is added by carrying the computations further. Higher terms will be necessary only when  $\delta_0$  becomes large, or when the plate covers more than  $2^\circ$  square.

Let us now seek to find a similar series for  $d\delta$ . The method is entirely analogous to the preceding, but the algebraic work is much more intricate. For we cannot now eliminate  $\delta$  and thus get rid of that quantity once for all. We must keep it in the reductions until the end, and then eliminate it by the relation

$$\delta = \delta_0 + \Delta \delta.$$

Let us consider again the expression for  $X$  in the form (9). Remembering the last of equations (8), we can transform this as follows : From (8) and (9)

$$X = \frac{\sin(a - a_0) \tan \rho}{\cos \rho_0 + \sin \rho_0 \tan \rho \cos(a - a_0)}. \quad (13)$$

From (8) and (10)

$$\tan \rho \cos(a - a_0) = \frac{\tan \rho_0 - Y}{Y \tan \rho_0 + 1}. \quad (14)$$

<sup>1</sup> See footnote, p. 443.



Hence, after slight reductions, from (13) and (14)

$$X = \sin(a - a_0) \tan \phi [Y \tan \phi_0 + 1] \cos \phi_0,$$

so that

$$\tan \phi = \frac{X}{\sin(a - a_0) [Y \tan \phi_0 + \cos \phi_0]}$$

or

$$\cot \delta = \frac{X}{\sin \Delta a [Y \cos \delta_0 + \sin \delta_0]}$$

and

$$\tan(\delta_0 + \Delta\delta) = \frac{\sin \Delta a [Y + \tan \delta_0]}{X \sec \delta_0}. \quad (15)$$

Expanding and reducing we obtain finally :

$$\tan \Delta\delta = \frac{\sin \Delta a [Y + \tan \delta_0] - X \sec \delta_0 \tan \delta_0}{X \sec \delta_0 + \sin \Delta a [Y + \tan \delta_0] \tan \delta_0}. \quad (16)$$

This may be written, substituting for the sine,

$$\Delta\delta = \tan^{-1} \frac{\left(\Delta a - \frac{\Delta a^3}{6} + \frac{\Delta a^5}{120}\right) [Y + \tan \delta_0] - X \sec \delta_0 \tan \delta_0}{X \sec \delta_0 + \left(\Delta a - \frac{\Delta a^3}{6} + \frac{\Delta a^5}{120}\right) [Y + \tan \delta_0] \tan \delta_0},$$

and if we replace here  $\Delta a$  by its value from (12), divide the numerator by the denominator, and then apply the formula for expanding the arc-tan., we get, to terms of the fourth order, the following series for  $\Delta\delta$  :

$$\left. \begin{aligned} \Delta\delta = & Y + D_1(X \sec \delta_0)^2 & D_1 = -\frac{1}{4} \sin 2 \delta_0, \\ & + D_2(X \sec \delta_0)^2 Y & D_2 = -\frac{1}{2}, \\ & + D_3 Y^3 & D_3 = -\frac{1}{3}, \\ & + D_4(X \sec \delta_0)^2 Y^2 & D_4 = -\frac{1}{2} \sin^2 \delta_0 \tan \delta_0, \\ & + D_5(X \sec \delta_0)^4 & D_5 = \frac{1}{8} (3 \sin \delta_0 \cos^3 \delta_0 \\ & & + \sin^3 \delta_0 \cos \delta_0). \end{aligned} \right\} \quad (17)^1$$

When  $\Delta a$  and  $\Delta\delta$  are known approximately from meridian observations a still more convenient form may be deduced from (12) and (17) by inversion of series. It is preferable in several ways: the labor involved in the calculations is slightly smaller and the results are somewhat more accurate, as the  $\Delta a$  and  $\Delta\delta$  used are free from errors of scale-value and orientation, which

<sup>1</sup> See footnote, p. 443.

is not the case with the measured  $X$  and  $Y$ . The formulæ, arranged for calculation to terms of the third order, are as follows :

$$\Delta a - X \sec \delta_0 = + \Delta a \Delta \delta \cdot \tan \delta_0 \sin 1'' \\ - \Delta a^3 \cdot \frac{1}{3} (1 - \frac{3}{2} \sin^2 \delta_0) \sin^2 1'' ; \quad (18)^1$$

$$\Delta \delta - Y = - \Delta a^2 \cdot \frac{1}{4} \sin 2\delta_0 \sin 1'' \\ - \Delta a^2 \Delta \delta \cdot \frac{1}{2} \cos 2\delta_0 \sin^2 1'' \\ - \Delta \delta^3 \cdot \frac{1}{3} \sin^2 1'' . \quad (19)^1$$

The simplicity and elegance of the above expressions are at once evident when we remember that  $\delta_0$  is the declination of the center of the plate, and is therefore constant for any group, or, in fact, for an entire zone. It is, however, necessary, that the position of the center should be known. As has previously been mentioned, Rutherford was careful to have this point coincide with some bright star; in the case of the Coma Plates the star selected was 12  $\epsilon$  (my no. 14). Taking thus the values of  $\Delta a$  and  $\Delta \delta$  from the *Catalog der Astronomischen Gesellschaft* (cf. the "LIST OF CATALOGUES" in Part I of the present paper), and applying formulæ (18) and (19) to each star, the quantities  $(\Delta a - X) \sec \delta_0$  and  $\Delta \delta - Y$  are obtained. I have collected them in TABLE VI. Since the rectangular coördinates,  $x$  and  $y$ , were measured from the same star as origin, it is evident that the table will give at once the corrections which have to be added to  $X \sec \delta_0$  and  $Y$ , *i. e.*, to the measured coördinates multiplied by the scale-value for the center of the plate, in order to change them to  $\Delta a$  and  $\Delta \delta$ . It is also plain that the table will be constant for all the plates, and that the corrections may therefore be applied equally well to the mean of all the determinations, as to each one separately. This I have done.

<sup>1</sup> NOTE.—Equ.'s (12), (17), (18) and (19) were first deduced by this method by Professor Jacoby. See his review of "Donner, Determination des Constants, etc.," in the *Vierteljahrsschrift* for 1895, p. 114, where these series, to terms of the fifth order are given, but without demonstration. Previously, Ball and Rambaut in *Trans. Roy. Irish Acad.*, XXX, Pt. IV, had deduced the first two of the above expansions to terms of the third order, but they were obtained by a process entirely different from that shown here.

A few words more on this subject may not be amiss. In the first paragraph of this section it is stated that the transformation correction is applied in order to change a measured distance on the plate into the corresponding actual distance on the sky. That is, however, not all: it does something more than that, when the formulæ (12), (17) or (18), (19) are used. For they presuppose that all the measured  $y$ 's are multiplied by  $p$ , and all the measured  $x$ 's by  $p \sec \delta_0$ , where  $p$  is the equatorial scale-value, and  $\delta_0$  is the declination of the center of the plate. But by this process an error is introduced, as all the distances in right ascension whose declination is greater than  $\delta_0$  become too small, and *vice versa*. The great advantage in using the formulæ mentioned, is, that they take account of this fact, and permit a constant scale-value to be used for all the stars. They include still another correction, namely that due to the curvature of the projections on the plate of the parallels of declination, which are not straight lines, but arcs tangent to the direction of the axis of  $X$ , at their intersection with the axis of  $Y$ . These considerations will explain why the quantities in the table are not symmetrical with respect to the center.

TABLE VI.—TRANSFORMATION CORRECTIONS.

| Star. | $\Delta\alpha - X \sec \delta_0$ | $\Delta\delta - Y$ | Star. | $\Delta\alpha - X \sec \delta_0$ | $\Delta\delta - Y$ |
|-------|----------------------------------|--------------------|-------|----------------------------------|--------------------|
| 1     | —10.109                          | —11.686            | 13    | +0.688                           | —0.233             |
| 2     | —4.301                           | —9.603             | 14    | .000                             | .000               |
| 3     | +20.249                          | —8.028             | 15    | —0.003                           | .000               |
| 4     | —2.645                           | —3.825             | 16    | +0.471                           | —0.176             |
| 5     | —13.245                          | —3.972             | 17    | —0.059                           | —0.029             |
| 6     | +1.119                           | —2.412             | 18    | +0.026                           | —0.321             |
| 7     | —1.015                           | —2.084             | 19    | +5.644                           | —0.938             |
| 8     | +1.413                           | —1.599             | 20    | +7.140                           | —1.323             |
| 9     | +9.188                           | —1.366             | 21    | +0.046                           | —1.916             |
| 10    | +7.124                           | —0.655             | 22    | +3.567                           | —2.610             |
| 11    | —4.585                           | —0.633             | 23    | —4.065                           | —2.958             |
| 12    | —3.785                           | —0.503             | 24    | —5.781                           | —5.046             |

**Refraction Corrections.**—Much has been written on the subject of photographic refraction, and several formulæ published designed to eliminate its effect from the measured rectan-

gular coördinates. I have used those of Professor Jacoby<sup>1</sup> which were deduced by him from Dr. Rambaut's formulæ published in the *Astronomische Nachrichten*, No. 3125. Let

$\varphi$  = the latitude of the place,  $+ 40^{\circ} 43' 50''$  in my case ;

$\theta - \alpha_0$  = the hour angle of the center of the plate,  $\theta$  being the "Sidereal Time" from TABLE I, and  $\alpha_0$  the right ascension of star 14, roughly corrected to the date of observation ;

$\delta_0$  = the declination of the center, Star 14 ;

$\beta$  = the constant of refraction computed for the center with the argument "True Zenith Distance,"  $\zeta_0$ , and multiplied by  $\frac{6}{5}$  to allow for the increased refrangibility of the actinic rays<sup>2</sup>; so that  $\beta = k' \cdot \frac{6}{5}$  (Chauvenet, Astr., Vol. I, §§ 119, 120).

Now compute the quantities

$$\tan N = \cos (\theta - \alpha_0) \cot \varphi$$

$$G = \cot (\delta_0 + N)$$

$$H = \tan (\theta - \alpha_0) \sin N \operatorname{cosec} (\delta_0 + N)$$

then will

$$\tan^2 \zeta_0 = G^2 + H^2 \quad (\text{Chauvenet, Vol. I, equ. (20)})$$

$$M_x = \beta (1 + H^2) \sin 1''$$

$$N_x = \beta (G - \tan \delta_0) H \sec \delta_0 \sin 1''$$

$$M_y = \beta (G + \tan \delta_0) H \cos \delta_0 \sin 1''$$

$$N_y = \beta (1 + G^2) \sin 1''$$

and the refraction corrections will be

$$\text{Correction to } X \sec \delta_0 = M_x \cdot X \sec \delta_0 + N_x \cdot Y$$

$$\text{Correction to } Y = M_y \cdot X \sec \delta_0 + N_y \cdot Y$$

where evidently the coefficients of  $X \sec \delta_0$  and  $Y$  in the second members are constant for each plate but vary for different plates.

<sup>1</sup> Astronomical Journal, No. 387.

<sup>2</sup> Cf. Scheiner and Rambaut, *Astron. Nachrichten*, No. 3255.

A very simple way of verifying the above formulæ is the following<sup>1</sup>: Bessel<sup>2</sup> gives corrections for clearing apparent differences in right ascension and declination, obtained by micrometric observations, from the effects of refraction in the form :

$$\begin{aligned}\Delta(a' - a) &= s\kappa [\tan^2 \zeta_0 \cos(\rho - q) \sin q \\ &\quad - \tan \zeta_0 \sin q \tan \delta_0 \cos \rho + \sin \rho] \sec' \delta_0 \\ \Delta(\delta' - \delta) &= s\kappa [\tan^2 \zeta_0 \cos(\rho - q) \cos q \\ &\quad + \tan \zeta_0 \sin q \tan \delta_0 \sin \rho + \cos \rho]\end{aligned}$$

where  $s$  and  $\rho$  are the measured distance and position angle,  $\zeta_0$  and  $q$  are the true zenith distance and parallactic angle at the middle point between the two stars, whose coördinates are  $(a, \delta)$  and  $(a', \delta')$ , and  $\delta_0$  is the declination of that point. Now (Chauvenet, Astronomy, Vol. II, p. 453)

$$\kappa \tan^2 \zeta_0 = b - a$$

where,  $r$  being the refraction,

$$\begin{aligned}a &= \frac{\sin \zeta_0}{\sin(\zeta_0 - r)} = \frac{1}{1 - r \cot \zeta_0} = \frac{1}{1 - k'} \\ b &= \frac{d\zeta_0}{d\zeta_0 - dr} = \frac{1}{1 - \frac{dr}{d\zeta_0}} = \frac{1}{1 - k' \sec^2 \zeta_0 - \frac{dk'}{d\zeta_0} \tan \zeta_0},\end{aligned}$$

placing  $\cos r = 1$ ,  $\sin r = r$  and remembering that  $r = k' \tan \zeta_0$  (Chauvenet, Vol. I, p. 171), where  $r$  and  $k'$  are expressed in parts of the radius. Expanding the expressions for  $a$  and  $b$  by division, we easily obtain

$$b - a = \kappa \tan^2 \zeta_0 = k' \tan^2 \zeta_0 + \frac{dk'}{d\zeta_0} \tan \zeta_0 + \dots,$$

the succeeding terms being higher powers in  $k'$  and  $\frac{dk'}{d\zeta_0}$  which can be neglected. For zenith distances less than  $70^\circ$  the term in  $\frac{dk'}{d\zeta_0}$  may also be neglected. For inside that limit we have

<sup>1</sup> Cf. Schlesinger's "Präsepe," Note, p. 285, where the above method was first pointed out

<sup>2</sup> Astronomische Untersuchungen, Vol. I, p. 166; or Chauvenet, Astronomy, Vol. II, p. 458.

$$\frac{dk'}{d\zeta_0} = \beta^{A'} \gamma^{\lambda'} \frac{d\alpha'}{d\zeta_0} \quad (\text{Cf. Chauvenet, Vol. I, p. 171})$$

with sufficient accuracy, as both  $A'$  and  $\lambda'$  are practically constant, and  $\beta$  and  $\gamma$  do not vary with the zenith distance. But this is only 0.00002 at the limit selected; and since the tangent of  $70^\circ$  is 2.7, the term  $\frac{dk'}{d\zeta_0} \tan \zeta_0$  will be inappreciable when  $\zeta_0$  is less than  $70^\circ$ . Hence we can write

$$\kappa \tan^2 \zeta_0 = k' \tan^2 \zeta_0$$

or

$$\kappa = k'$$

with sufficient accuracy for photographic work, where  $s$  is not large.

Let us then substitute in the original formulæ for  $\Delta(a' - a)$  and  $\Delta(\delta' - \delta)$  from the following equations :

$$\begin{aligned} \kappa &= k' \\ s \sin p &= X \\ s \cos p &= Y \\ \tan \zeta_0 \sin q &= H \\ \tan \zeta_0 \cos q &= G \end{aligned}$$

and they become

$$\begin{aligned} \Delta(a' - a) &= k' X \sec \delta_0 (1 + H^2) + k' Y (G - \tan \delta_0) H \sec \delta_0 \\ \Delta(\delta' - \delta) &= k' X (G + \tan \delta_0) H + k' Y (1 + G^2) \end{aligned}$$

where  $k'$  is expressed in parts of the radius. These formulæ are evidently identical with Professor Jacoby's except for the factor 66/65 by which  $k'$  must be multiplied in order to obtain  $\beta$ . It should be observed that in the above equations terms in the second and higher powers of  $s$  are neglected; for we take account neither of transformation corrections, nor of the fact that in Bessel's original formulæ the quantities  $\zeta_0$  and  $\delta_0$  are intended to apply to the middle point between the two stars, whereas we transfer them to the end of the arc. This is, however, entirely legitimate for most photographic plates.

I subjoin TABLE VII which shows the values of the four factors  $M_x$ ,  $N_x$ ,  $M_y$ ,  $N_y$  for all of my plates.



TABLE VII.—REFRACTION COEFFICIENTS.

| Plate. | $M_x$     | $N_x$     | $M_y$     | $N_y$     |
|--------|-----------|-----------|-----------|-----------|
| I      | +0.000307 | -0.000017 | +0.000048 | +0.000313 |
| II     | .000331   | .000022   | .000078   | .000319   |
| III    | .000287   | .000001   | .000003   | .000306   |
| IV     | .000339   | .000023   | .000091   | .000317   |
| V      | .000375   | .000021   | .000126   | .000327   |
| VI     | .000424   | .000011   | .000168   | .000342   |
| VII    | .000362   | .000021   | .000119   | .000319   |
| VIII   | .000409   | .000013   | .000159   | .000334   |
| IX     | .000303   | .000017   | .000049   | .000308   |
| X      | .000320   | .000021   | .000072   | .000312   |
| XI     | .000347   | .000023   | .000100   | .000319   |
| XII    | .000384   | .000019   | .000134   | .000329   |
| XIII   | .000294   | .000015   | .000044   | .000302   |
| XIV    | .000312   | .000021   | .000068   | .000306   |

**Precession, Nutation, and Aberration.**—None of these need be taken into account. For as regards the first two, they, being due to motions of the earth, cannot affect the configuration of the stars, although they shift the axes of reference. The absolute distances between the stars will, therefore, be unaffected by these causes, but the differences in right ascension and declination will be changed. If, then, we compute the constants by the method to be detailed later, *i*, *e*., by comparing certain stars on the plate with their positions as obtained from meridian observations reduced to some convenient epoch, then it is evident that the resulting right ascensions and declinations from the plate will be referred to the same epoch, without the need of applying any corrections for precession or nutation. For the changes due to these causes consist partly in a motion of translation, and partly in a motion of rotation of the axes; the former will be entirely eliminated, while the latter will be included in the orientation correction.

Aberration may also be neglected. For Bessel<sup>1</sup> has shown that it changes the position angles about a point equally, while it affects all the distances, in whatever direction, by a constant

<sup>1</sup> *Astronomische Untersuchungen*, Vol. I, p. 207; or Chauvenet, *Astronomy*, Vol. II, p. 466.

factor only. Its whole effect will therefore be included in the scale-value and orientation corrections, when these are obtained by the method now to be described.

**Constants of the Plates.**—Four quantities must be known for each plate, in order that we may determine the absolute positions of the stars whose coördinates have been measured. They are: the right ascension  $\alpha_0$  and the declination  $\delta_0$  of the center, or origin; the value in seconds of arc of one division of the scale; and the angle made by the axes to which the measurements are referred, with the axes of reference in the celestial sphere. To obtain them, we must compare the measured coördinates of certain stars ("standards") with the corresponding distances of the same stars, from the same point as origin, obtained from meridian observations. Matters will be greatly facilitated by a knowledge of approximate values for these constants. As regards my plates, such information was available. The position of the center which coincides with star 14 (12 $\epsilon$  Comæ), was accurately known; the approximate scale-value was placed at

$$1 \text{ mm.} = 52''.87,$$

that being the result of a previous reduction of Rutherford's photographs of the Pleiades; while the orientation correction, due to the rotation of the axes, would be necessarily small, owing to the manner in which the plate was adjusted in the measuring machine.

We must now obtain the distances  $\Delta a = a - a_0$ , and  $\Delta \delta = \delta - \delta_0$ , for certain stars on the plates. Let us return to Part I, Section III of this paper. We find there (p. 396) a catalogue of twelve stars suitable for this purpose. Of these, the following eleven are sufficiently well observed to serve as "standards": 2, 3, 5, 6, 10, 11, d, 14, 18, 19, 20. These are Chase's numbers; they correspond to my numbers 1, 2, 4, 5, 9, 10, 14, 15, 21, 22, 23, respectively. In the following I shall designate them by the latter numbers only. But before proceeding to obtain  $\Delta a$  and  $\Delta \delta$  for these stars, we must apply a correction for proper motion.

For, the photographs being taken at three different dates, namely 1870.3 (Plates I-III), 1875.4 (Plates IV-VIII), and 1876.4 (Plates IX-XIV), the relative positions of the standards will not be the same for them all, due to the cause mentioned. As the epoch of reduction is to be 1875, we must not apply any correction for precession or nutation, otherwise what has been said above regarding this matter would not apply. We can, then, construct TABLE VIII. This table gives the Right Ascensions and Proper Motions in Right Ascension, and the Declinations and Proper Motions in Declination, for 1875. Then follow six columns showing the seconds of the Right Ascensions and Declinations with the proper motions applied to reduce them to the three dates mentioned; and in the last two columns will be found the Weights in Right Ascension and in Declination, respectively, of each star for 1870 and 1875. The same weights were used for 1875 and 1876. They were calculated by reversing the process for obtaining the probable errors explained in Part I, Sect. II, "FORMULÆ FOR ADJUSTMENT." From these quantities we can then obtain  $\Delta\alpha$  and  $\Delta\delta$  with their weights for each "standard" on every plate.

Now let us compute for each standard on each plate the quantities  $n_x$  and  $n_y$  as follows: From TABLE V we obtain  $x$  and  $y$  for each star. Form the products  $X \sec \delta_0 = x \sec \delta_0^* \cdot 52''.87$  and  $Y = y \cdot 52''.87$ . Correct these for refraction by means of TABLE VII and the corresponding formulæ, and apply the transformation corrections from TABLE VI. Subtract from the sums thus obtained the corresponding  $\Delta\alpha$  or  $\Delta\delta$ : the differences will be  $n_x \sec \delta_0$  and  $n_y$ . It is then evident that  $n_x$  and  $n_y$  should be zero, if it were not for errors of observation, and for errors in the assumed constants. We are to find the values of the latter. Let us introduce the notation:

- $p$  = the correction to the assumed scale-value, so that the true value is  $52''.87 (1 + p)$ ;  
 $r$  = the orientation correction, or small angle through which the axes must be rotated in the direction of decreasing position angles;

TABLE VIII. — COÖRDINATES OF THE STANDARDS.

| No. | Right Asc.    | At 1875. |               | At 1870.3. |                    | At 1875.4.         |                    | At 1876.4.         |                    | 1870.          |                | 1875.          |                |
|-----|---------------|----------|---------------|------------|--------------------|--------------------|--------------------|--------------------|--------------------|----------------|----------------|----------------|----------------|
|     |               | $\mu$ .  | Declination.  | $\mu'$ .   | Sec. of $\alpha$ . | Sec. of $\delta$ . | Sec. of $\alpha$ . | Sec. of $\delta$ . | Sec. of $\delta$ . | Wt. $\alpha$ . | Wt. $\delta$ . | Wt. $\alpha$ . | Wt. $\delta$ . |
| 1   | 183° 5' 43.50 | —0.039   | 26° 52' 58.24 | +0.086     | 43.68              | 57.84              | 43.48              | 58.27              | 43.45              | 58.36          | 4.0            | 4.2            | 4.2            |
| 2   | 10 55.96      | —0.074   | 26 42 10.65   | —0.009     | 56.31              | 10.69              | 55.93              | 10.65              | 55.86              | 10.64          | 5.6            | 6.3            | 4.9            |
| 4   | 30 16.70      | —0.210   | 26 41 42.94   | +0.030     | 17.69              | 42.80              | 16.62              | 42.95              | 16.41              | 42.98          | 5.6            | 6.4            | 4.9            |
| 5   | 30 37.80      | —0.106   | 27 19 2.26    | —0.106     | 38.30              | 2.76               | 37.76              | 2.22               | 37.65              | 2.11           | 7.6            | 12.0           | 5.7            |
| 9   | 41 53.76      | —0.249   | 25 43 14.48   | +0.144     | 54.93              | 13.80              | 53.66              | 14.54              | 53.41              | 14.68          | 3.5            | 4.3            | 2.9            |
| 10  | 47 16.77      | —0.048   | 25 41 28.01   | +0.004     | 17.00              | 27.99              | 16.75              | 28.01              | 16.70              | 28.02          | 2.9            | 3.1            | 2.3            |
| 14  | 184 3 18.03   | —0.033   | 26 32 23.98   | +0.007     | 18.19              | 23.95              | 18.02              | 23.98              | 17.98              | 23.99          | 27.8           | 32.3           | 23.5           |
| 15  | 3 34.40       | +0.006   | 26 31 20.26   | +0.088     | 34.37              | 19.85              | 34.40              | 20.30              | 34.41              | 20.38          | 1.9            | 2.6            | 4.2            |
| 21  | 26 44.18      | —0.030   | 26 32 40.72   | +0.015     | 44.32              | 40.65              | 44.17              | 40.73              | 44.14              | 40.74          | 8.9            | 9.7            | 7.5            |
| 22  | 30 32.58      | —0.038   | 26 47 31.03   | —0.004     | 32.76              | 31.05              | 32.56              | 31.03              | 32.53              | 31.02          | 16.5           | 16.8           | 13.8           |
| 23  | 32 33.99      | —0.048   | 26 16 33.15   | +0.016     | 34.22              | 33.07              | 33.97              | 33.16              | 33.92              | 33.17          | 10.9           | 10.6           | 8.8            |

$k$  = the correction in seconds of arc of a great circle to be added to the assumed right ascension of the center ;

$c$  = the correction in seconds of arc of a great circle to be added to the assumed declination of the center.

Then the measured coördinates in seconds of arc of a great circle,  $X$  and  $Y$ , will require the following corrections :

Due to erroneous scale-value,

$$\text{Correction to } X = + pX$$

$$\text{Correction to } Y = + pY;$$

Due to orientation error, remembering that  $r$  is small,

$$\text{Correction to } X = + rY$$

$$\text{Correction to } Y = - rX;$$

Due to errors in the assumed position of the center,

$$\text{Correction to } X = + k$$

$$\text{Correction to } Y = + c.$$

It is evident that if we add the sum of these corrections to  $X$  and  $Y$  corrected for refraction and for transformation errors, we should obtain  $\Delta a \cos \delta_0$  and  $\Delta \delta$  respectively. We have, therefore, from each star, two equations of the form

$$k + pX + rY + n_x = v_1$$

$$c + pY - rX + n_y = v_2$$

where the  $v$ 's, as usual, are the residual errors due to inaccuracy of the observations.

Let us now form, for each plate, equations like the above for every standard measured ; we shall get a set of observation equations, from which the constants can be determined by the method of least squares. Usually, when all the  $n$ 's have the same weight, or when the weights of corresponding equations in the two coördinates are equal, it is possible to abridge the labor considerably by means of certain formulæ deduced by Professor Jacoby.<sup>1</sup> As given by him, they apply to the case of equal weights only, but they might easily be generalized. I could not make use of this

<sup>1</sup> Monthly Notices, May, 1896, p. 424.

method, however. For, owing to the manner in which  $n_x$  and  $n_y$  were obtained (namely, by using  $\Delta a$  and  $\Delta \delta$  obtained from catalogue positions), their weights are quite irregular. The formulæ of the general theory, therefore, had to be used. Each equation was first multiplied by the square root of the weight of the star on which the absolute term depended. This, although not theoretically correct (since the weight should take account of the uncertainty in the position of the central star, and also of that of the measured photographic coördinates), was found to be sufficiently accurate, owing to the minuteness of the unknowns. For the same reason, no appreciable error was committed by dividing the coefficients  $X$  and  $Y$  by 100, and retaining only the first place of decimals, while the arithmetical work was greatly simplified thereby. The following set of observation equations was thus obtained :

$$+ p_1 k - + p_1 X p' + + p_1 Y r' + + p_1 n_x = 0$$

$$+ p_n c + + p_n Y p' - + p_n X r' - + p_n n_y = 0$$

where  $\sqrt{p_i}$  is the square root of the weight,  $(n-1)$  is the number of standards used,  $p' = 100p$ ,  $p$  being the scale-value desired, and  $r' = 100r$ . To find the unknowns, the following method was used, a demonstration of which is given in Jordan, *Handbuch der Vermessungskunde*, Vol. I, p. 97 (4th edit.). Form the two sets of normals :

$$[p_1] k + [p_1 X_1] p' + [p_1 Y_1] r' + [p_1 n_x] = 0$$

$$[p_1 X_1 X_1] p' + [p_1 X_1 Y_1] r' + [p_1 X_1 n_x] = 0$$

$$[p_1 Y_1 Y_1] r' + [p_1 Y_1 n_x] = 0$$

$$[p_2] c + [p_2 Y_2] p' - [p_2 X_2] r' + [p_2 n_y] = 0$$

$$[p_2 Y_2 Y_2] p' - [p_2 X_2 Y_2] r' + [p_2 Y_2 n_y] = 0$$

$$[p_2 X_2 X_2] r' - [p_2 X_2 n_y] = 0$$

where the subscripts <sub>1</sub> refer to the equations containing  $k$ , and the subscripts <sub>2</sub> to those containing  $c$ . Now eliminate  $k$  and  $c$  as usual, obtaining

$$(113)$$



$$k = -\frac{[\dot{p}_1 X_1]}{[\dot{p}_1]} \dot{p}' - \frac{[\dot{p}_1 Y_1]}{[\dot{p}_1]} r' - \frac{[\dot{p}_1 n_z]}{[\dot{p}_1]}$$

$$c = -\frac{[\dot{p}_2 Y_2]}{[\dot{p}_2]} \dot{p}' + \frac{[\dot{p}_2 X_2]}{[\dot{p}_2]} r' - \frac{[\dot{p}_2 n_y]}{[\dot{p}_2]},$$

and

$$[\dot{p}_1 X_1 X_1 \cdot \mathbf{I}] \dot{p}' + [\dot{p}_1 X_1 Y_1 \cdot \mathbf{I}] r' + [\dot{p}_1 X_1 n_z \cdot \mathbf{I}] = 0$$

$$[\dot{p}_1 Y_1 Y_1 \cdot \mathbf{I}] r' + [\dot{p}_1 Y_1 n_z \cdot \mathbf{I}] = 0$$

$$[\dot{p}_2 Y_2 Y_2 \cdot \mathbf{I}] \dot{p}' + [\dot{p}_2 X_2 Y_2 \cdot \mathbf{I}] r' + [\dot{p}_2 Y_2 n_y \cdot \mathbf{I}] = 0$$

$$[\dot{p}_2 X_2 X_2 \cdot \mathbf{I}] r' + [\dot{p}_2 X_2 n_y \cdot \mathbf{I}] = 0$$

Add the first and third, and the second and fourth of the last equations, term to term, and from the resulting equations obtain  $\dot{p}'$  and  $r'$ . The values will be identically the same as if all the four unknowns had been eliminated from one set of normals by the general method.

The weights of the unknowns could, in this case, at once be written down, with sufficient accuracy. For owing to the fact that the weights in right ascension and in declination of the observation equations are nearly equal, we have

$$[\dot{p}_1 X_1 X_1 \cdot \mathbf{I}] + [\dot{p}_2 Y_2 Y_2 \cdot \mathbf{I}] = [\dot{p}_1 Y_1 Y_1 \cdot \mathbf{I}] + [\dot{p}_2 X_2 X_2 \cdot \mathbf{I}]$$

nearly and

$$[\dot{p}_1 X_1 Y_1 \cdot \mathbf{I}] + [\dot{p}_2 X_2 Y_2 \cdot \mathbf{I}]$$

small, so that we can place (cf. Chauvenet, *Astronomy*, Vol. II, p. 537)

$$\text{Wt. of } \dot{p}' = [\dot{p}_1 X_1 X_1 \cdot \mathbf{I}] + [\dot{p}_2 Y_2 Y_2 \cdot \mathbf{I}]$$

$$\text{Wt. of } r' = [\dot{p} Y Y \cdot 3]$$

where  $[\dot{p} Y Y \cdot 3]$  denotes the coefficient of  $r'$  in the last elimination equation. Similarly, in the inverted elimination, the coefficients of  $\dot{p}'$  and  $r'$  are very large compared to those of  $k$  and  $c$ , so that at once

$$\text{Wt. } k = [\dot{p}_1] \text{ of the equations containing } k$$

$$\text{Wt. } c = [\dot{p}_2] \text{ of the equations containing } c.$$

Knowing the weights, the probable errors were then obtained in the usual manner from the residuals.

It now remains only to make use of the constants obtained by the methods described above. This is a simple matter. For we have to apply to the measured coördinates the corrections

$$\begin{array}{llll} + p \cdot X \sec \delta_0 + r \sec \delta_0 \cdot Y + k \sec \delta_0 & \text{to } X \sec \delta_0 \\ + p \cdot Y & - r \cdot X & + c & \text{to } Y \end{array}$$

due to errors in the assumed constants, and

$$\begin{array}{ll} + M_x \cdot X \sec \delta_0 + N_x Y & \text{to } X \sec \delta_0 \\ + M_y \cdot X \sec \delta_0 + N_y Y & \text{to } Y \end{array}$$

due to refraction. If then we add  $X \sec \delta_0$  and  $Y$ , corrected by the process explained above to  $\alpha_0$  and  $\delta_0$  respectively, where  $\alpha_0$  and  $\delta_0$  are the assumed coördinates of the center, we will obtain for each star certain quantities,  $\alpha_1$  and  $\delta_1$ , which are defined by the equations

$$\begin{aligned} \alpha &= \alpha_1 + T_\alpha \\ \delta &= \delta_1 + T_\delta \end{aligned}$$

where  $\alpha$  and  $\delta$  are the right ascension and the declination respectively of the given star, and  $T_\alpha$  and  $T_\delta$  are the corresponding transformation corrections.  $\alpha_1$  and  $\delta_1$  may be called the "projected" coördinates of the star. Collecting all these operations together, it is evident that we can write the following formulæ :

$$\begin{aligned} \alpha_1 &= (\mathbf{I} + p + M_x) X \sec \delta_0 + (N_x + r \sec \delta_0) Y + (\alpha_0 + k \sec \delta_0) \\ \delta_1 &= (\mathbf{I} + p + N_y) Y + (M_y - r \cos \delta_0) X \sec \delta_0 + (\delta_0 + c), \end{aligned}$$

and

$$\alpha = \alpha_1 + T_\alpha, \quad \delta = \delta_1 + T_\delta$$

and when taken in connection with the preceding discussion, it is evident that these equations express in mathematical language all the steps necessary to transform the measured rectangular coördinates on the plates,  $x$  and  $y$ , into the corresponding right ascensions and declinations on the celestial sphere.

## IV. Results.

**Constants.**—Making the least square solution for each plate as explained Sect. III, we get the constants set down in TABLE IX. They all depend on eleven standards, except in the case of Plate I, where two of these are missing, owing to inaccurate pointing of the telescope. The probable errors computed for  $p$  and  $r$  in no case differed by more than a unit in the last place; I have therefore given only one value, which applies to both these quantities.

TABLE IX.—CONSTANTS.

| Plate. | $p$       | $r$       | Probable Error of $p$ or $r$ . | $k$    | Prob. Error of $k$ . | $c$    | Prob. Error of $c$ . |
|--------|-----------|-----------|--------------------------------|--------|----------------------|--------|----------------------|
| I      | +0.000240 | +0.000117 | ±0.000030                      | +0.135 | ±0.056               | —0.119 | ±0.053               |
| II     | + 238     | + 205     | ± 28                           | +0.131 | ±0.058               | —0.083 | ±0.054               |
| III    | + 308     | 192       | ± 26                           | +0.148 | ±0.052               | —0.174 | ±0.048               |
| IV     | + 233     | 194       | ± 26                           | —0.073 | ±0.050               | —0.178 | ±0.047               |
| V      | + 265     | 540       | ± 28                           | +0.003 | ±0.056               | —0.100 | ±0.052               |
| VI     | + 260     | 187       | ± 26                           | +0.166 | ±0.052               | —0.161 | ±0.049               |
| VII    | + 210     | 92        | ± 24                           | +0.139 | ±0.046               | —0.084 | ±0.044               |
| VIII   | + 215     | 118       | ± 27                           | —0.018 | ±0.053               | —0.176 | ±0.050               |
| IX     | + 290     | 140       | ± 24                           | +0.160 | ±0.048               | —0.095 | ±0.045               |
| X      | + 283     | 11        | ± 24                           | +0.069 | ±0.048               | —0.060 | ±0.045               |
| XI     | + 307     | 60        | ± 25                           | +0.089 | ±0.049               | —0.089 | ±0.046               |
| XII    | + 266     | 199       | ± 29                           | +0.093 | ±0.057               | —0.108 | ±0.053               |
| XIII   | + 307     | 132       | ± 24                           | +0.161 | ±0.048               | —0.107 | ±0.045               |
| XIV    | + 304     | 25        | ± 24                           | +0.093 | ±0.048               | —0.017 | ±0.045               |

It will be seen that the probable errors agree very well, so that the final positions from all the plates are entitled to an equal amount of confidence. A probable error in  $p$  or  $r$  of  $\pm 0.000025$  corresponds to an uncertainty of about  $0''.08$  of arc of a great circle in the position of the most outlying star. The great diversity in the values of  $r$  is due for the most part to the accidental position in which the plate was set in the measuring machine.

The following are the residuals obtained by introducing the values of the constants given above in the respective observation equations (p. 452) :

From the Right Ascensions :

| Plate. | Star 1. | Star 2. | Star 4. | Star 5. | Star 9. | Star 10. | Star 14. | Star 15. | Star 21. | Star 22. | Star 23. |
|--------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|----------|
| I      |         |         | +0.14   | -0.25   | -0.03   | -1.03    | +0.14    | +0.16    | -0.12    | -0.10    | +0.26    |
| II     | -1.02   | 0.00    | +0.08   | +0.15   | -0.12   | -1.09    | +0.13    | +0.44    | -0.04    | -0.05    | +0.24    |
| III    | -0.39   | -0.17   | -0.06   | +0.15   | -0.05   | -1.08    | +0.15    | +0.28    | -0.11    | -0.12    | +0.31    |
| IV     | -0.32   | +0.19   | +0.28   | +0.25   | -0.10   | -0.81    | -0.07    | +0.24    | +0.04    | -0.28    | +0.43    |
| V      | -0.48   | +0.12   | +0.20   | +0.21   | -0.28   | -1.05    | .00      | +0.40    | -0.08    | -0.26    | +0.55    |
| VI     | -0.46   | +0.10   | +0.16   | +0.11   | -0.41   | -1.08    | +0.17    | +0.29    | -0.30    | -0.15    | +0.31    |
| VII    | -0.42   | +0.06   | +0.08   | +0.10   | -0.22   | -1.16    | +0.14    | +0.12    | -0.32    | +0.02    | +0.25    |
| VIII   | -0.44   | +0.09   | +0.15   | +0.28   | -0.12   | -0.82    | -0.02    | +0.51    | -0.16    | -0.24    | +0.46    |
| IX     | -0.44   | -0.02   | +0.26   | +0.12   | -0.21   | -1.01    | +0.16    | +0.27    | -0.30    | -0.18    | +0.31    |
| X      | -0.52   | +0.04   | +0.25   | +0.28   | -0.37   | -0.98    | +0.07    | +0.10    | -0.26    | -0.07    | +0.36    |
| XI     | -0.52   | -0.05   | +0.34   | +0.33   | -0.38   | -0.99    | +0.09    | +0.15    | -0.16    | -0.15    | +0.32    |
| XII    | -0.70   | +0.31   | +0.28   | +0.12   | -0.47   | -1.09    | +0.09    | +0.06    | -0.15    | -0.16    | +0.45    |
| XIII   | -0.64   | +0.03   | +0.21   | +0.16   | -0.35   | -0.91    | +0.16    | +0.19    | -0.27    | -0.11    | +0.30    |
| XIV    | -0.50   | +0.06   | +0.27   | +0.21   | -0.42   | -1.07    | +0.09    | -0.03    | -0.22    | -0.09    | +0.42    |
| Means. | -0.49   | +0.06   | +0.19   | +0.16   | -0.25   | -1.01    | +0.09    | +0.23    | -0.17    | -0.14    | +0.36    |

From the Declinations :

| Plate. | Star 1. | Star 2. | Star 4. | Star 5. | Star 9. | Star 10. | Star 14. | Star 15. | Star 21. | Star 22. | Star 23. |
|--------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|----------|
| I      |         |         | -0.21   | +0.11   | +0.07   | +0.34    | -0.12    | +0.53    | +0.20    | -0.15    | +0.17    |
| II     | +0.28   | -0.19   | -0.08   | -0.21   | +0.26   | +0.31    | -0.08    | +0.52    | +0.17    | -0.07    | +0.16    |
| III    | +0.22   | -0.07   | -0.11   | -0.12   | +0.23   | +0.33    | -0.17    | +0.58    | +0.22    | +0.03    | +0.11    |
| IV     | +0.12   | +0.03   | -0.09   | +0.08   | -0.15   | +0.16    | -0.18    | +0.21    | +0.22    | -0.01    | +0.23    |
| V      | +0.08   | -0.06   | -0.05   | -0.02   | +0.01   | +0.13    | -0.10    | +0.16    | +0.16    | -0.10    | +0.29    |
| VI     | +0.09   | -0.08   | -0.01   | -0.08   | +0.03   | +0.27    | -0.16    | +0.13    | +0.21    | +0.08    | +0.16    |
| VII    | -0.14   | -0.06   | -0.01   | -0.14   | +0.25   | +0.18    | -0.08    | +0.03    | +0.11    | +0.13    | +0.03    |
| VIII   | +0.24   | -0.06   | -0.03   | -0.01   | +0.11   | +0.07    | -0.18    | +0.14    | +0.30    | -0.03    | +0.17    |
| IX     | -0.03   | -0.06   | -0.09   | +0.05   | +0.08   | +0.19    | -0.10    | .00      | +0.10    | .00      | +0.19    |
| X      | -0.10   | -0.01   | -0.02   | -0.12   | -0.12   | +0.20    | -0.06    | -0.07    | +0.20    | -0.01    | +0.24    |
| XI     | -0.02   | -0.13   | -0.13   | -0.06   | -0.04   | +0.18    | -0.09    | +0.23    | +0.15    | +0.04    | +0.19    |
| XII    | +0.01   | -0.13   | -0.07   | -0.02   | +0.14   | +0.19    | -0.11    | +0.09    | +0.24    | -0.07    | +0.23    |
| XIII   | .00     | -0.09   | -0.03   | -0.08   | +0.18   | +0.32    | -0.11    | -0.01    | +0.11    | +0.06    | +0.12    |
| XIV    | -0.09   | -0.06   | -0.14   | -0.14   | +0.06   | +0.17    | -0.02    | +0.05    | +0.10    | +0.04    | +0.12    |
| Means  | +0.05   | -0.07   | -0.08   | -0.05   | +0.10   | +0.22    | -0.11    | +0.18    | +0.18    | .00      | +0.17    |

ANNALS N. Y. ACAD. SCI., April 4, 1900.—29.

A consideration of these residuals brings out several interesting facts. In the first place it is evident that they are almost entirely due to errors in the meridian places, as the residuals from the different plates for any one star run very nearly alike. But a more important matter is their size. On the whole they are fairly large, although perhaps not more so than might have been expected from the probable errors of the standard stars. At least is this the case with the declinations; the right ascensions show a much greater uncertainty. This is due partly to the fact that  $x$ 's on the plates are more difficult to measure, owing to the elongation of the images; but the chief cause is the greater inaccuracy of the catalogue right ascensions. The statement regarding this matter in Part I, Sect. I, "WEIGHTS," is thus fully borne out. It is important to note, that the residuals seem to increase more rapidly than the probable errors of the stars, so that the poorly determined standards show relatively larger residuals than the others. These considerations lead to the following conclusions: Unless several stars on the plates can be found well determined in a considerable number of reliable catalogues, it will not pay to go through the laborious process of obtaining the positions of the standards by the method which I employed. If good modern observations are available, the constants determined from them will be quite sufficiently accurate; provided, of course, that the date of observation is not very distant from the date of exposure of the plate, or otherwise, that the proper motion of the stars be accurately known.

To satisfy myself on this point, I deduced the constants of Plate III, using values of  $n_x$  and  $n_y$  obtained by comparison of nine of my stars with Romberg's places. The weights assigned were the same as had been given to this catalogue throughout the present paper. I found thus:

$$\begin{aligned} k &= -0.469 & \pm 0.107 \\ c &= -0.256 & \pm 0.107 \\ p &= +0.000433 & \pm 0.000061 \\ r &= +0.000245 & \pm 0.000061 \end{aligned}$$

and the residuals:

|             | Star 1. | Star 2. | Star 4. | Star 5. | Star 14. | Star 15. | Star 21. | Star 22. | Star 23. |
|-------------|---------|---------|---------|---------|----------|----------|----------|----------|----------|
| In $\alpha$ | —0.65   | +0.25   | +1.10   | +0.69   | —0.47    | —0.21    | +0.67    | —0.35    | +0.36    |
| In $\delta$ | +0.03   | +0.18   | —0.23   | +0.06   | —0.26    | +0.28    | +0.37    | +0.07    | +0.06    |

Both the residuals and the probable errors, it is true, are rather larger than when the constants were obtained by the more elaborate method.\* But considering the quantities themselves, it will be seen, that both  $p$  and  $k$  differ from the values previously obtained by more than the sums of the probable errors. In the latter case, the reason for this discrepancy is an unexplained systematic difference between Romberg's places, and the positions of my standards. The discordance in  $p$  cannot be thus explained. It is much more serious, as it affects, not the group as a whole, but changes the relative positions of the stars. It appears then, that the constants are by far the most unreliable of all the quantities used in the reduction of the plates; and it would seem that any labor spent on them, outside of what is absolutely necessary, is but poorly repaid.

**True Scale-Value.**—It has been stated that the computed scale-value,  $52''.87(1 + p)$ , involves the effect of aberration. It may be useful for future reductions of the Rutherford photographs to set down the true quantities. Although for accurate work it will in general be necessary to perform the least square solution for each plate, and thus independently to obtain the scale-value, cases might arise, when a close approximation would be sufficient, or when the number of available standards is so small, that no reliance can be placed on the resulting constants. Then, too, it is possible that a relation may exist between the "focus" and the scale-value.

To find the form of the correction to be added to  $52''.87(1 + p)$  in order to eliminate the effect of aberration, we let

$\sigma$  = the *true* distance in seconds of arc, from the center to any star on the plate;

$n$  = the *measured* number of millimeters on the plate, from the center to the star whose distance is  $\sigma$ .



Then it is evident, from the method by which the constants are derived (*i. e.*, by comparison with catalogue positions) that, but for errors of observation,

$$\frac{\sigma}{n} = 52''.87(1 + p). \quad (1)$$

But evidently,  $n$  is too great by the amount of the aberration, being the measured distance on the plate. Hence, if we let

$$\begin{aligned} \gamma &= -(\tan \varepsilon \sin \delta_0 + \sin \alpha_0 \cos \delta_0) \cdot \sin 1'' \\ \delta &= \cos \alpha_0 \cos \delta_0 \cdot \sin 1'', \end{aligned}$$

where  $\varepsilon$  is the obliquity of the ecliptic, and  $\alpha_0$  and  $\delta_0$  are the coördinates of the central star, roughly corrected to the time of exposure of the plate, then will (cf. Chauvenet, *Astronomy*, Vol. II, p. 467)

$$\sigma(1 + C\gamma + D\delta)$$

be the measured distance on the plate in seconds of arc.  $C$  and  $D$  in this formula represent the Besselian day numbers, and may be obtained from the Ephemeris. We find, then, evidently

$$\text{True Scale-Value} = S = \frac{\sigma(1 + C\gamma + D\delta)}{n} \quad (2)$$

or, remembering equation (1), and neglecting small terms

$$S = 52''.87(1 + p + C\gamma + D\delta). \quad (3)$$

A correction for the temperature at which the plate was measured might also be applied, using for this purpose the coefficient of expansion determined by Dr. Schlesinger (*"Präsepe,"* p. 223). But as that quantity is not very reliable, and as the corrections are necessarily very small, being in no case as large as 0.0007 if we use the value of  $v$  as given in the place referred to, while, on the other hand, the mean uncertainty of  $p$  is more than 0.0013, I have felt justified in neglecting the same.

We obtain then the following table :

TABLE X.—TRUE SCALE VALUES.

| Plate. | $1 + p$ . | Corr. for Aberr. | Corr. Scale Value. | Tel. Ther. | Focus. |
|--------|-----------|------------------|--------------------|------------|--------|
| I      | +1.000240 | +0.000062        | 52.8860            | 53         | 8.4    |
| II     | + 238     | + 062            | 52.8859            | 53         | 8.4    |
| III    | + 308     | + 063            | 52.8896            | 58         | 8.5    |
| IV     | + 233     | + 088            | 52.8870            | 60         | 7.7    |
| V      | + 265     | + 088            | 52.8887            | 60         | 7.7    |
| VI     | + 260     | + 088            | 52.8884            | 60         | 7.7    |
| VII    | + 210     | + 088            | 52.8858            | 70         | 7.6    |
| VIII   | + 215     | + 088            | 52.8860            | 70         | 7.6    |
| IX     | + 290     | + 086            | 52.8899            | 60         | 7.7    |
| X      | + 283     | + 086            | 52.8895            | 60         | 7.7    |
| XI     | + 307     | + 086            | 52.8908            | 60         | 7.7    |
| XII    | + 266     | + 086            | 52.8886            | 60         | 7.7    |
| XIII   | + 307     | + 086            | 52.8908            | 65         | 7.65   |
| XIV    | + 304     | + 086            | 52.8906            | 65         | 7.65   |

The mean scale-value is :

$$52''.8884.$$

In forming the above table no account has been taken of the temperature at which the plate was exposed, nor of the reading of the "focus" and "telescopic thermometer" (which are copied from TABLE I). A discussion of the effects of these causes on the scale-value must be postponed until a much larger number of Rutherford plates have been independently reduced.

**Separate Results.**—Employing the constants of TABLE IX as explained in Sect. III, we obtain the "projected" right ascensions and declinations,  $\alpha_1$  and  $\delta_1$ , given on the succeeding pages. From them we can find the final coördinates,  $\alpha$  and  $\delta$ , and the proper motions. The latter were deduced from my results, in connection with Chase's (cf. p. 343, foot-note, of the present paper) positions, for all those stars which he observed. Only two others were found on a sufficient number of plates to warrant an investigation for proper motion. The method employed for all cases when the observations were distributed over more than two distinct dates, was that fully explained in Part I, Sect. II, "FORMULÆ FOR ADJUSTMENT." The epoch being 1875, Chase's positions were reduced from 1892 to that date, using his geometric precessions. A systematic correction

of  $-0''.44$  in R. A. and  $+0''.72$  in Decl., indicated by direct comparison with my standards, was then applied. As date of observation I assumed uniformly 1891.6. This differs in no case by more than .3 of a year from the true value, and the calculations are greatly simplified by using the same dates throughout, as then  $T_0$  and  $\Sigma(CD)$  remain constant. Unit weight was assigned to all the observations, including those of Chase. This was warranted by the probable errors, and the formulæ of Part I, p. 365 were greatly simplified thereby. They become

$$a_0 = \frac{\Sigma(B)}{m} - \beta, \quad T_0 = \frac{\Sigma(t)}{m} - \beta'$$

and

$$\Delta\mu_0 = \frac{\Sigma(CE)}{\Sigma(C^2)}, \quad \mu = -\Delta\mu_0,$$

where the notation is the same as before and  $m$  denotes the number of observations. The  $a_0$  and  $\delta_0$  thus obtained include Chase's position, however. As I wished to have an independent determination, deduced solely from the photographic observations, these quantities were not used, but a value for 1875 was obtained directly by the following method: The proper motion having been found as explained above, the measured positions were corrected to 1875 by applying to them the quantity  $\mu(1875 - t)$ . The mean was then taken of the corrected places excluding Chase's position, and this is the final "projected" coördinate for 1875, *i. e.*,  $a_1$  or  $\delta_1$ , as the case may be, of the succeeding tables. The probable error of a single observation was obtained from all the residuals by Peters' formula as given by Rogers in his zone (North Decl.  $50^\circ$  to  $55^\circ$ ) of the *Catalog der Astronomischen Gesellschaft*, p. (10), which is

$$r = \pm 0.8453 \frac{[+v]}{\sqrt{n(n-n'')}} ,$$

$n$  being the total number of residuals used, and  $n''$  being the number of stars. We find thus

$$r^a = \pm 0''.0939 = \pm 0''.0840 \text{ in equatorial seconds,} \\ r_\delta = \pm 0''.0595,$$

as the probable error of a single observation. The probable error of a catalogue position depending on fourteen plates is therefore

$$r_a = \pm 0''.025, \quad r_\delta = \pm 0''.016,$$

the  $r_a$  being in seconds of arc of a parallel of declination through the center of the plate. It should be mentioned, that the residuals as used are assumed to be all of equal weight. This, while not theoretically correct (since some of the positions include, besides errors of direct observation, the uncertainty of the proper motion) is sufficiently accurate, owing to the small value of the probable errors of the proper motions, and the fact that  $(1875-t)$  is in no case larger than 4.7.

The probable errors of the proper motions were obtained by the usual formulæ (cf. Part I, Sect. II, "FORMULÆ FOR ADJUSTMENT")

$$r_1 = \pm 0.6745 \sqrt{\frac{[vv]}{m-2}}, \quad r_\mu = \frac{r_1}{\sqrt{[C^2]}}.$$

The  $v$ 's used here were the same as before, including, however, the residuals obtained from Chase's position reduced to 1875 and corrected for proper motion. Neglecting the fact that the mean  $a_1$  or  $\delta_1$  does not include Chase's observations, which can be done without appreciable effect on the result, it is easy to show that the residuals obtained as explained above have the same value as they would have if computed by the method described in Part I, Sect. III, "STAR TABLES." For by the latter method

$$\begin{aligned} v_a &= a_0 - B a' \\ &= a_1 + a_2 + \dots + a_m \\ &\quad - \left[ a_1 + \Delta\mu_0 \frac{m t_1 - (t_1 + t_2 + \dots + t_m)}{m} \right] \\ &= \frac{a_1 + a_2 + \dots + a_m}{m} + \frac{\Delta\mu_0 (t_1 + t_2 + \dots + t_m)}{m} \\ &\quad - a_1 - \Delta\mu_0 t_1 \end{aligned}$$

for the case of equal weights of all the  $a$ 's. But by the first method

$$v_a = \frac{a_1 + \Delta\mu_0(t_1 - 1875) + a_2 + \Delta\mu_0(t_2 - 1875) + \cdots + a_m + \Delta\mu_0(t_m - 1875)}{m} \\ - [a_1 + \Delta\mu_0(t_1 - 1875)] \\ = \frac{a_1 + a_2 + \cdots + a_m}{m} + \frac{\Delta\mu_0(t_1 + t_2 + \cdots + t_m)}{m} - a_1 - \Delta\mu_0 t_1,$$

so that the two results are identical. We can therefore use the formula for  $v_\mu$  given above, and, with the exception of the slight inaccuracy mentioned, the results will be theoretically correct. All the probable errors of the proper motion in the succeeding tables were obtained in this way.

On the following pages are recorded the separate positions of all the stars on the plates. Chase's place, reduced to 1875, is printed in *Italics* at the end of each list. The headings are plain when taken in connection with the preceding discussion. At the end of each table are given the final means,  $\alpha_1$  and  $\delta_1$ , the date of observation, and the proper motion with its probable error.  $\alpha_1$  and  $\delta_1$ , as has been stated, do not include Chase's observations. For the stars numbered 1, 2, 4, 5, 6, 7, 8, 9, 10, 14, 15, 21, 22, 23, and 24,  $\mu$  and  $\mu'$  were computed by the method detailed above. The other proper motions given in the tables were\* obtained by subtracting the mean of my determinations from Chase's position, and dividing the difference by the interval in years. They are inclosed in brackets, for the sake of distinction. No probable error was computed for them. The dates of observation are evidently the same in all cases, and are as follows: Plates I-III, 1870.3, Plates IV-VIII, 1875.4, Plates IX-XIV, 1876.4, and Chase 1891.6. They are not repeated in the tables, but at the end of each is given the mean date of observation (excluding Chase) corresponding to the star.

## STAR I.

| Plate                                                   | Right Ascension.   |                   |             |       | Declination.                                           |                    |             |        |
|---------------------------------------------------------|--------------------|-------------------|-------------|-------|--------------------------------------------------------|--------------------|-------------|--------|
|                                                         | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ . | At Epoch of Plate.                                     | Corr. for $\mu'$ . | Epoch 1875. | $v'$ . |
| II                                                      | 183° 5' 52.74      | —0.33             | 52.41       | +0.63 | 26° 53' 9.81                                           | +0.34              | 10.15       | —0.17  |
| III                                                     | 5 53.36            | —0.33             | 53.03       | +0.01 | 53 9.75                                                | +0.34              | 10.09       | —0.11  |
| IV                                                      | 5 53.23            | +0.03             | 53.26       | —0.22 | 53 10.08                                               | —0.03              | 10.05       | —0.07  |
| V                                                       | 5 53.06            | +0.03             | 53.09       | —0.05 | 53 10.04                                               | —0.03              | 10.01       | —0.03  |
| VI                                                      | 5 53.09            | +0.03             | 53.12       | —0.08 | 53 10.05                                               | —0.03              | 10.02       | —0.04  |
| VII                                                     | 5 53.13            | +0.03             | 53.16       | —0.12 | 53 9.82                                                | —0.03              | 9.79        | +0.19  |
| VIII                                                    | 5 53.11            | +0.03             | 53.14       | —0.10 | 53 10.19                                               | —0.03              | 10.16       | —0.18  |
| IX                                                      | 5 53.08            | +0.10             | 53.18       | —0.14 | 53 10.00                                               | —0.10              | 9.90        | +0.08  |
| X                                                       | 5 52.99            | +0.10             | 53.09       | —0.05 | 53 9.95                                                | —0.10              | 9.85        | +0.13  |
| XI                                                      | 5 52.98            | +0.10             | 53.08       | —0.04 | 53 10.03                                               | —0.10              | 9.93        | +0.05  |
| XII                                                     | 5 52.78            | +0.10             | 52.88       | +0.16 | 53 10.05                                               | —0.10              | 9.95        | —0.03  |
| XIII                                                    | 5 52.86            | +0.10             | 52.96       | +0.08 | 53 10.04                                               | —0.10              | 9.94        | +0.04  |
| XIV                                                     | 5 52.99            | +0.10             | 53.09       | —0.05 | 53 9.96                                                | —0.10              | 9.86        | +0.12  |
| Chase                                                   | 5 51.66            | +1.16             | 52.82       | +0.22 | 53 11.31                                               | —1.21              | 10.10       | —0.12  |
| $\alpha_1$ 183° 5' 53.04<br>Date of Observation, 1875.1 |                    |                   |             |       | $\delta_1$ 26° 53' 9.98<br>Date of Observation, 1875.1 |                    |             |        |
| $\mu$ —0.070 ± 0.0085                                   |                    |                   |             |       | $\mu'$ +0.073 ± 0.0046                                 |                    |             |        |

## STAR 2.

| Plate.                                                  | Right Ascension.   |                   |             |       | Declination.                                            |                    |             |        |
|---------------------------------------------------------|--------------------|-------------------|-------------|-------|---------------------------------------------------------|--------------------|-------------|--------|
|                                                         | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ . | At Epoch of Plate.                                      | Corr. for $\mu'$ . | Epoch 1875. | $v'$ . |
| II                                                      | 183° 11' 0.62      | —0.18             | 0.44        | —0.11 | 26° 42' 20.11                                           | +0.04              | 20.15       | +0.03  |
| III                                                     | 11 0.43            | —0.18             | 0.25        | +0.08 | 42 20.22                                                | +0.04              | 20.26       | —0.08  |
| IV                                                      | 11 0.48            | +0.02             | 0.50        | —0.17 | 42 20.27                                                | .00                | 20.27       | —0.09  |
| V                                                       | 11 0.39            | +0.02             | 0.41        | —0.08 | 42 20.20                                                | .00                | 20.20       | —0.02  |
| VI                                                      | 11 0.37            | +0.02             | 0.39        | —0.06 | 42 20.17                                                | .00                | 20.17       | +0.01  |
| VII                                                     | 11 0.30            | +0.02             | 0.32        | +0.01 | 42 20.19                                                | .00                | 20.19       | —0.01  |
| VIII                                                    | 11 0.34            | +0.02             | 0.36        | —0.03 | 42 20.18                                                | .00                | 20.18       | .00    |
| IX                                                      | 11 0.15            | +0.05             | 0.20        | +0.13 | 42 20.18                                                | —0.01              | 20.17       | +0.01  |
| X                                                       | 11 0.21            | +0.05             | 0.26        | +0.07 | 42 20.24                                                | —0.01              | 20.23       | —0.05  |
| XI                                                      | 11 0.11            | +0.05             | 0.16        | +0.17 | 42 20.12                                                | —0.01              | 20.11       | +0.07  |
| XII                                                     | 11 0.49            | +0.05             | 0.54        | —0.21 | 42 20.11                                                | —0.01              | 20.10       | +0.08  |
| XIII                                                    | 11 0.19            | +0.05             | 0.24        | +0.09 | 42 20.15                                                | —0.01              | 20.14       | +0.04  |
| XIV                                                     | 11 0.23            | +0.05             | 0.28        | +0.05 | 42 20.18                                                | —0.01              | 20.17       | —0.01  |
| Chase                                                   | 10 59.71           | +0.65             | 0.36        | —0.03 | 42 20.34                                                | —0.13              | 20.21       | —0.03  |
| $\alpha_1$ 183° 11' 0.33<br>Date of Observation, 1875.1 |                    |                   |             |       | $\delta_1$ 26° 42' 20.18<br>Date of Observation, 1875.1 |                    |             |        |
| $\mu$ —0.039 ± 0.0045                                   |                    |                   |             |       | $\mu'$ +0.008 ± 0.0020                                  |                    |             |        |



## STAR 3.

| Plate.               | Right Ascension.   |                   |             |                | $v$ . | Declination.         |                    |             |   | $v$ .         |
|----------------------|--------------------|-------------------|-------------|----------------|-------|----------------------|--------------------|-------------|---|---------------|
|                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. |                |       | At Epoch of Plate.   | Corr. for $\mu'$ . | Epoch 1875. |   |               |
| VI                   | 183° 13' 56.61     | 0.00              | 56.61       | —              |       | 25° 45' 25.94        | —0.01              | 25.93       | — |               |
| Chase                | 13 56.79           | —0.18             | 56.61       | —              |       | 45 26.28             | —0.35              | 25.93       | — |               |
| $a_1$                |                    |                   |             | 183° 13' 56.61 |       | $\delta_2$           |                    |             |   | 25° 45' 25.93 |
| Date of Observation, |                    |                   |             | 1875.4         |       | Date of Observation, |                    |             |   | 1875.4        |
| $\mu$                |                    |                   |             | [+0.011]       |       | $\mu$                |                    |             |   | [+0.021]      |

## STAR 4.

| Plate.               | Right Ascension.   |                   |             |                 | $v$ . | Declination.         |                    |             |       | $v$ .           |
|----------------------|--------------------|-------------------|-------------|-----------------|-------|----------------------|--------------------|-------------|-------|-----------------|
|                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. |                 |       | At Epoch of Plate.   | Corr. for $\mu'$ . | Epoch 1875. |       |                 |
| I                    | 183° 30' 20.48     | —0.85             | 19.63       | —0.07           |       | 26° 41' 46.42        | +0.17              | 46.59       | +0.10 |                 |
| II                   | 30 20.43           | —0.85             | 19.58       | —0.02           |       | 41 46 55             | +0.17              | 46.72       | —0.03 |                 |
| III                  | 30 20.27           | —0.85             | 19 42       | +0.14           |       | 41 46.51             | +0.17              | 46.68       | +0.01 |                 |
| IV                   | 30 19.58           | +0.07             | 19.65       | —0.09           |       | 41 46.69             | —0.01              | 46.68       | +0.01 |                 |
| V                    | 30 19.48           | +0.07             | 19.55       | +0.01           |       | 41 46.73             | —0.01              | 46.72       | —0.03 |                 |
| VI                   | 30 19.45           | +0.07             | 19.52       | +0.04           |       | 41 46.76             | —0.01              | 46.75       | —0.06 |                 |
| VII                  | 30 19.36           | +0.07             | 19.43       | +0.13           |       | 41 46.76             | —0.01              | 46.75       | —0.06 |                 |
| VIII                 | 30 19.43           | +0.07             | 19.50       | +0.06           |       | 41 46.75             | —0.01              | 46.74       | —0.05 |                 |
| IX                   | 30 19.34           | +0.25             | 19.59       | —0.03           |       | 41 46.71             | —0.05              | 46.66       | +0.03 |                 |
| X                    | 30 19.33           | +0.25             | 19 58       | —0.02           |       | 41 46.79             | —0.05              | 46.74       | —0.05 |                 |
| XI                   | 30 19.43           | +0.25             | 19 68       | —0.12           |       | 41 46.68             | —0.05              | 46.63       | +0.06 |                 |
| XII                  | 30 19.36           | +0.25             | 19 61       | —0.05           |       | 41 46.74             | —0.05              | 46.69       | 0.00  |                 |
| XIII                 | 30 19.30           | +0.25             | 19.55       | +0.01           |       | 41 46.77             | —0.05              | 46.72       | —0.03 |                 |
| XIV                  | 30 19.36           | +0.25             | 19.61       | —0.05           |       | 41 46.66             | —0.05              | 46.61       | +0.08 |                 |
| Chase                | 30 19.52           | +3.00             | 19.52       | +0.04           |       | 41 47.26             | —0.60              | 46.66       | +0.03 |                 |
| $a_1$                |                    |                   |             | 183° 30' 19.56  |       | $\delta_1$           |                    |             |       | 26° 41' 46.69   |
| Date of Observation, |                    |                   |             | 1874.7          |       | Date of Observation, |                    |             |       | 1874.7          |
| $\mu$                |                    |                   |             | —0.181 ± 0.0028 |       | $\mu'$               |                    |             |       | +0.036 ± 0.0019 |

## STAR 5.

| Plate.                      | Right Ascension.      |                      |                |       | Declination.                |                       |                |       |
|-----------------------------|-----------------------|----------------------|----------------|-------|-----------------------------|-----------------------|----------------|-------|
|                             | At Epoch of<br>Plate. | Corr.<br>for $\mu$ . | Epoch<br>1875. | $v$ . | At Epoch of<br>Plate.       | Corr.<br>for $\mu'$ . | Epoch<br>1875. | $v$ . |
| I                           | 183° 30' 51.28        | -0.42                | 50.86          | +0.37 | 27° 19' 6.84                | -0.45                 | 6.39           | -0.21 |
| II                          | 30 51.72              | -0.42                | 51.30          | -0.07 | 19 6.52                     | -0.45                 | 6.07           | +0.11 |
| III                         | 30 51.72              | -0.42                | 51.30          | -0.07 | 19 6.62                     | -0.45                 | 6.17           | +0.01 |
| IV                          | 30 51.28              | +0.04                | 51.32          | -0.09 | 19 6.27                     | +0.04                 | 6.31           | -0.13 |
| V                           | 30 51.24              | +0.04                | 51.28          | -0.05 | 19 6.18                     | +0.04                 | 6.22           | -0.04 |
| VI                          | 30 51.13              | +0.04                | 51.17          | +0.06 | 19 6.12                     | +0.04                 | 6.16           | +0.02 |
| VII                         | 30 51.12              | +0.04                | 51.16          | +0.07 | 19 6.06                     | +0.04                 | 6.10           | +0.08 |
| VIII                        | 30 51.31              | +0.04                | 51.35          | -0.12 | 19 6.18                     | +0.04                 | 6.22           | -0.04 |
| IX                          | 30 51.04              | +0.13                | 51.17          | +0.06 | 19 6.12                     | +0.13                 | 6.25           | -0.07 |
| X                           | 30 51.20              | +0.13                | 51.33          | -0.11 | 19 5.96                     | +0.13                 | 6.09           | +0.09 |
| XI                          | 30 51.26              | +0.13                | 51.39          | -0.17 | 19 6.01                     | +0.13                 | 6.14           | +0.04 |
| XII                         | 30 51.02              | +0.13                | 51.15          | +0.08 | 19 6.07                     | +0.13                 | 6.20           | -0.02 |
| XIII                        | 30 51.07              | +0.13                | 51.20          | +0.03 | 19 6.00                     | +0.13                 | 6.13           | +0.05 |
| XIV                         | 30 51.11              | +0.13                | 51.24          | -0.01 | 19 5.94                     | +0.13                 | 6.07           | +0.11 |
| Chase                       | 30 49.65              | +1.49                | 51.14          | -0.09 | 19 4.63                     | +1.59                 | 6.22           | -0.04 |
| $a_1$ 183° 30' 51.23        |                       |                      |                |       | $\delta_1$ 27° 19' 6.18     |                       |                |       |
| Date of Observation, 1874.7 |                       |                      |                |       | Date of Observation, 1874.7 |                       |                |       |
| $\mu$ -0.090 $\pm$ 0.0049   |                       |                      |                |       | $\mu'$ -0.096 $\pm$ 0.0034  |                       |                |       |

## STAR 6.

| Plate.                      | Right Ascension.      |                      |                |       | Declination.                |                       |                |       |
|-----------------------------|-----------------------|----------------------|----------------|-------|-----------------------------|-----------------------|----------------|-------|
|                             | At Epoch of<br>Plate. | Corr.<br>for $\mu$ . | Epoch<br>1875. | $v$ . | At Epoch of<br>Plate.       | Corr.<br>for $\mu'$ . | Epoch<br>1875. | $v$ . |
| I                           | 183° 36' 56.99        | -0.30                | 56.69          | -0.21 | 26° 27' 38.54               | +0.02                 | 38.56          | +0.14 |
| II                          | 36 56.91              | -0.30                | 56.61          | -0.13 | 27 38.85                    | +0.02                 | 38.87          | -0.17 |
| III                         | 36 56.47              | -0.30                | 56.17          | +0.31 | 27 38.71                    | +0.02                 | 38.73          | -0.03 |
| IV                          | 36 56.51              | +0.03                | 56.54          | -0.06 | 27 38.62                    | .00                   | 38.62          | +0.08 |
| V                           | 36 56.49              | +0.03                | 56.52          | -0.04 | 27 38.61                    | .00                   | 38.61          | +0.09 |
| VI                          | 36 56.41              | +0.03                | 56.44          | +0.04 | 27 38.63                    | .00                   | 38.63          | +0.07 |
| VII                         | 36 56.02              | +0.03                | 56.05          | +0.43 | 27 38.65                    | .00                   | 38.65          | +0.05 |
| VIII                        | 36 56.77              | +0.03                | 56.80          | -0.32 | 27 38.75                    | .00                   | 38.75          | -0.05 |
| X                           | 36 56.58              | +0.09                | 56.67          | -0.19 | 27 38.82                    | -0.01                 | 38.81          | -0.11 |
| XI                          | 36 56.18              | +0.09                | 56.27          | +0.21 | 27 38.77                    | -0.01                 | 38.76          | -0.06 |
| XII                         | 36 56.38              | +0.09                | 56.47          | +0.01 | 27 38.71                    | -0.01                 | 38.70          | .00   |
| XIII                        | 36 56.67              | +0.09                | 56.76          | -0.28 | 27 38.68                    | -0.01                 | 38.67          | +0.03 |
| XIV                         | 36 56.23              | +0.09                | 56.32          | +0.16 | 27 38.79                    | -0.01                 | 38.78          | -0.08 |
| $a_1$ 183° 36' 56.48        |                       |                      |                |       | $\delta_1$ 26° 27' 38.70    |                       |                |       |
| Date of Observation, 1874.6 |                       |                      |                |       | Date of Observation, 1874.6 |                       |                |       |
| $\mu$ -0.064 $\pm$ 0.0187   |                       |                      |                |       | $\mu'$ +0.004 $\pm$ 0.0073  |                       |                |       |

## STAR 7.

| Right Ascension.            |                    |                   |             |                             | Declination.       |                    |             |       |  |
|-----------------------------|--------------------|-------------------|-------------|-----------------------------|--------------------|--------------------|-------------|-------|--|
| Plate.                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ .                       | At Epoch of Plate. | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |  |
| I                           | 183° 38' 53.30     | —0.12             | 53.18       | —0.08                       | 26° 37' 16.63      | —0.02              | 16.61       | +0.07 |  |
| II                          | 38 53.25           | —0.12             | 53.13       | —0.03                       | 37 16.71           | —0.02              | 16.69       | —0.01 |  |
| III                         | 38 53.14           | —0.12             | 53.02       | +0.08                       | 37 16.80           | —0.02              | 16.78       | —0.10 |  |
| IV                          | 38 53.22           | +0.01             | 53.23       | —0.13                       | 37 16.58           | .00                | 16.58       | +0.10 |  |
| V                           | 38 53.11           | +0.01             | 53.12       | —0.02                       | 37 16.76           | .00                | 16.76       | —0.08 |  |
| VI                          | 38 53.03           | +0.01             | 53.04       | +0.06                       | 37 16.80           | .00                | 16.80       | —0.12 |  |
| VII                         | 38 52.89           | +0.01             | 52.90       | +0.20                       | 37 16.67           | .00                | 16.67       | +0.01 |  |
| VIII                        | 38 53.23           | +0.01             | 53.24       | —0.14                       | 37 16.71           | .00                | 16.71       | —0.03 |  |
| IX                          | 38 52.91           | +0.04             | 52.95       | +0.15                       | 37 16.50           | +0.01              | 16.51       | +0.17 |  |
| X                           | 38 53.04           | +0.04             | 53.08       | +0.02                       | 37 16.66           | +0.01              | 16.67       | +0.01 |  |
| XI                          | 38 53.23           | +0.04             | 53.27       | —0.17                       | 37 16.81           | +0.01              | 16.82       | —0.14 |  |
| XII                         | 38 53.09           | +0.04             | 53.13       | —0.03                       | 37 16.79           | +0.01              | 16.80       | —0.12 |  |
| XIII                        | 38 53.18           | +0.04             | 53.22       | —0.12                       | 37 16.49           | +0.01              | 16.50       | +0.18 |  |
| XIV                         | 38 52.88           | +0.04             | 52.92       | +0.18                       | 37 16.63           | +0.01              | 16.64       | +0.04 |  |
| Chase                       | 38 52.70           | +0.42             | 53.12       | —0.02                       | 37 16.63           | +0.07              | 16.70       | —0.02 |  |
| $a_1$ 183° 38' 53.10        |                    |                   |             | $\delta_1$ 26° 37' 16.68    |                    |                    |             |       |  |
| Date of Observation, 1874.7 |                    |                   |             | Date of Observation, 1874.7 |                    |                    |             |       |  |
| $\mu$ —0.025 $\pm$ 0.0044   |                    |                   |             | $\mu'$ —0.004 $\pm$ 0.0038  |                    |                    |             |       |  |

## STAR 8.

| Right Ascension.            |                    |                   |             |                             | Declination.       |                    |             |        |  |
|-----------------------------|--------------------|-------------------|-------------|-----------------------------|--------------------|--------------------|-------------|--------|--|
| Plate.                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ .                       | At Epoch of Plate. | Corr. for $\mu'$ . | Epoch 1875. | $v'$ . |  |
| I                           | 183° 41' 47.75     | —0.27             | 47.48       | +0.02                       | 26° 24' 55.40      | —0.09              | 55.31       | —0.13  |  |
| II                          | 41' 47.78          | —0.27             | 47.51       | —0.01                       | 24 55.30           | —0.09              | 55.21       | —0.03  |  |
| III                         | 41' 47.44          | —0.27             | 47.17       | +0.33                       | 24 55.37           | —0.09              | 55.28       | —0.10  |  |
| IV                          | 41' 47.70          | +0.02             | 47.72       | —0.22                       | 24 55.66           | +0.01              | 55.17       | +0.01  |  |
| V                           | 41' 47.34          | +0.02             | 47.36       | +0.14                       | 24 55.08           | +0.01              | 55.09       | +0.09  |  |
| VI                          | 41' 47.57          | +0.02             | 47.59       | —0.09                       | 24 55.20           | +0.01              | 55.21       | —0.03  |  |
| VII                         | 41' 47.65          | +0.02             | 47.67       | —0.17                       | 24 55.21           | +0.01              | 55.22       | —0.04  |  |
| VIII                        | 41' 47.64          | +0.02             | 47.66       | —0.16                       | 24 55.14           | +0.01              | 55.15       | +0.03  |  |
| IX                          | 41' 47.29          | +0.08             | 47.37       | +0.13                       | 24 55.09           | +0.03              | 55.12       | +0.06  |  |
| X                           | 41' 47.34          | +0.08             | 47.42       | +0.08                       | 24 55.07           | +0.03              | 55.10       | +0.08  |  |
| XI                          | 41' 47.60          | +0.08             | 47.68       | —0.18                       | 24 55.10           | +0.03              | 55.13       | +0.05  |  |
| XII                         | 41' 47.36          | +0.08             | 47.44       | +0.06                       | 24 55.23           | +0.03              | 55.26       | —0.08  |  |
| XIII                        | 41' 47.27          | +0.08             | 47.35       | +0.15                       | 24 55.18           | +0.03              | 55.21       | —0.03  |  |
| XIV                         | 41' 47.43          | +0.08             | 47.51       | —0.01                       | 24 55.07           | +0.03              | 55.10       | +0.08  |  |
| Chase                       | 41' 46.46          | +0.95             | 47.41       | +0.09                       | 24 54.93           | +0.33              | 55.26       | —0.08  |  |
| $a_1$ 183° 41' 47.50        |                    |                   |             | $\delta_1$ 26° 24' 55.18    |                    |                    |             |        |  |
| Date of Observation, 1874.7 |                    |                   |             | Date of Observation, 1874.7 |                    |                    |             |        |  |
| $\mu$ —0.057 $\pm$ 0.0063   |                    |                   |             | $\mu'$ —0.020 $\pm$ 0.0027  |                    |                    |             |        |  |

## STAR 9.

| Plate.                      | Right Ascension.   |                   |             |       | Declination.                |                    |             |       |
|-----------------------------|--------------------|-------------------|-------------|-------|-----------------------------|--------------------|-------------|-------|
|                             | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ . | At Epoch of Plate.          | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| I                           | 183° 41' 45.71     | —1.36             | 44.35       | —0.07 | 25° 43' 15.23               | +0.63              | 15.86       | +0.06 |
| II                          | 41 45.61           | —1.36             | 44.25       | +0.03 | 43 15.44                    | +0.63              | 16.07       | —0.15 |
| III                         | 41 45.68           | —1.36             | 44.32       | —0.04 | 43 15.40                    | +0.63              | 16.03       | —0.11 |
| IV                          | 41 44.37           | +0.12             | 44.49       | —0.21 | 43 15.76                    | —0.05              | 15.71       | +0.21 |
| V                           | 41 44.16           | +0.12             | 44.28       | .00   | 43 15.92                    | —0.05              | 15.87       | +0.05 |
| VI                          | 41 44.02           | +0.12             | 44.14       | +0.14 | 43 15.93                    | —0.05              | 15.88       | +0.04 |
| VII                         | 41 44.23           | +0.12             | 44.35       | —0.07 | 43 16.16                    | —0.05              | 16.11       | —0.19 |
| VIII                        | 41 44.34           | +0.12             | 44.46       | —0.18 | 43 16.01                    | —0.05              | 15.96       | —0.04 |
| IX                          | 41 43.99           | +0.40             | 44.39       | —0.11 | 43 16.12                    | —0.19              | 15.93       | —0.01 |
| X                           | 41 43.82           | +0.40             | 44.22       | +0.06 | 43 15.93                    | —0.19              | 15.74       | —0.18 |
| XI                          | 41 43.80           | +0.40             | 44.20       | +0.08 | 43 16.01                    | —0.19              | 15.82       | +0.10 |
| XII                         | 41 43.69           | +0.40             | 44.09       | +0.19 | 43 16.19                    | —0.19              | 16.00       | —0.08 |
| XIII                        | 41 43.83           | +0.40             | 44.23       | —0.05 | 43 16.22                    | —0.19              | 16.03       | —0.11 |
| XIV                         | 41 43.74           | +0.40             | 44.14       | +0.14 | 43 16.09                    | —0.19              | 15.90       | +0.02 |
| Chase                       | 41 39.53           | +4.80             | 44.33       | —0.05 | 43 18.19                    | —2.21              | 15.98       | —0.06 |
| $\alpha_1$ 183° 41' 44.28   |                    |                   |             |       | $\delta_1$ 25° 43' 15.92    |                    |             |       |
| Date of Observation, 1874.7 |                    |                   |             |       | Date of Observation, 1874.7 |                    |             |       |
| $\mu$ —0.289 $\pm$ 0.0044   |                    |                   |             |       | $\mu'$ +0.133 $\pm$ 0.0044  |                    |             |       |

## STAR 10.

| Plate.                      | Right Ascension.   |                   |             |       | Declination.                |                    |             |       |
|-----------------------------|--------------------|-------------------|-------------|-------|-----------------------------|--------------------|-------------|-------|
|                             | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ . | At Epoch of Plate.          | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| I                           | 183° 47' 8.72      | —0.18             | 8.54        | —0.02 | 25° 41' 28.99               | —0.07              | 28.92       | —0.04 |
| II                          | 47 8.66            | —0.18             | 8.48        | +0.04 | 41 28.95                    | —0.07              | 28.88       | .00   |
| III                         | 47 8.68            | —0.18             | 8.50        | +0.02 | 41 28.98                    | —0.07              | 28.91       | —0.03 |
| IV                          | 47 8.73            | +0.02             | 8.75        | —0.23 | 41 28.82                    | +0.01              | 28.83       | +0.05 |
| V                           | 47 8.44            | +0.02             | 8.46        | +0.06 | 41 28.80                    | +0.01              | 28.81       | +0.07 |
| VI                          | 47 8.43            | +0.02             | 8.45        | +0.07 | 41 28.93                    | +0.01              | 28.94       | —0.06 |
| VII                         | 47 8.33            | +0.02             | 8.35        | +0.17 | 41 28.85                    | +0.01              | 28.86       | +0.02 |
| VIII                        | 47 8.71            | +0.02             | 8.73        | —0.21 | 41 28.74                    | +0.01              | 28.75       | +0.13 |
| IX                          | 47 8.44            | +0.05             | 8.49        | +0.03 | 41 28.86                    | +0.02              | 28.88       | .00   |
| X                           | 47 8.48            | +0.05             | 8.53        | —0.01 | 41 28.88                    | +0.02              | 28.90       | —0.02 |
| XI                          | 47 8.48            | +0.05             | 8.53        | —0.01 | 41 28.86                    | +0.02              | 28.88       | .00   |
| XII                         | 47 8.36            | +0.05             | 8.41        | +0.11 | 41 28.86                    | +0.02              | 28.88       | .00   |
| XIII                        | 47 8.56            | +0.05             | 8.61        | —0.09 | 41 28.99                    | +0.02              | 29.01       | —0.13 |
| XIV                         | 47 8.39            | +0.05             | 8.44        | +0.08 | 41 28.84                    | +0.02              | 28.86       | +0.02 |
| Chase                       | 47 7.87            | +0.65             | 8.52        | .00   | 41 28.66                    | +0.23              | 28.89       | —0.01 |
| $\alpha_1$ 183° 47' 8.52    |                    |                   |             |       | $\delta_1$ 25° 41' 28.88    |                    |             |       |
| Date of Observation, 1874.7 |                    |                   |             |       | Date of Observation, 1874.7 |                    |             |       |
| $\mu$ —0.039 $\pm$ 0.0041   |                    |                   |             |       | $\mu'$ —0.014 $\pm$ 0.0022  |                    |             |       |

## STAR 11.

| Plate.               | Right Ascension.   |                   |             |                 | Declination.         |                    |             |       |
|----------------------|--------------------|-------------------|-------------|-----------------|----------------------|--------------------|-------------|-------|
|                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ .           | At Epoch of Plate.   | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| IV                   | 183° 51' 50.55"    | +0.02             | 50.57       | +0.02           | 27° 18' 8.60"        | -0.01              | 8.59        | -0.53 |
| VI                   | 51 50.42           | +0.02             | 50.44       | +0.15           | 18 7.69              | -0.01              | 7.68        | +0.38 |
| VIII                 | 51 50.73           | +0.02             | 50.75       | -0.16           | 18 7.91              | -0.01              | 7.90        | +0.16 |
| Chase                | 51 49.89           | +0.70             | 50.59       | .00             | 18 8.28              | -0.22              | 8.06        | .00   |
| $\alpha_1$           |                    |                   |             | 183° 51' 50.59" | $\delta_1$           |                    |             |       |
| Date of Observation, |                    |                   |             | 1875.4          | Date of Observation, |                    |             |       |
| $\mu$                |                    |                   |             | [ - 0.042 ]     | $\mu'$               |                    |             |       |
|                      |                    |                   |             |                 | [ + 0.013 ]          |                    |             |       |

## STAR 12.

| Plate.               | Right Ascension.   |                   |             |                | Declination.         |                    |             |       |
|----------------------|--------------------|-------------------|-------------|----------------|----------------------|--------------------|-------------|-------|
|                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ .          | At Epoch of Plate.   | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| IV                   | 183° 53' 2.09"     | —                 | 2.09        | -0.05          | 27° 14' 35.44"       | —                  | 35.44       | +0.05 |
| VI                   | 53 1.84            | —                 | 1.84        | +0.20          | 14 35.50             | —                  | 35.50       | -0.01 |
| VIII                 | 53 2.19            | —                 | 2.19        | -0.15          | 14 35.53             | —                  | 35.53       | -0.04 |
| $\alpha_1$           |                    |                   |             | 183° 53' 2.04" | $\delta_1$           |                    |             |       |
| Date of Observation, |                    |                   |             | 1875.4         | Date of Observation, |                    |             |       |
| $\mu$                |                    |                   |             | ?              | $\mu'$               |                    |             |       |
|                      |                    |                   |             |                | ?                    |                    |             |       |

## STAR 13.

| Plate.               | Right Ascension.   |                   |             |                | Declination.         |                    |             |       |
|----------------------|--------------------|-------------------|-------------|----------------|----------------------|--------------------|-------------|-------|
|                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ .          | At Epoch of Plate.   | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| IV                   | 183° 55' 3.93"     | —                 | 3.93        | -0.16          | 26° 22' 46.96"       | —                  | 46.96       | -0.04 |
| V                    | 55 3.58            | —                 | 3.58        | +0.19          | 22 46.85             | —                  | 46.85       | +0.07 |
| VI                   | 55 3.68            | —                 | 3.68        | +0.09          | 22 46.98             | —                  | 46.98       | -0.06 |
| VIII                 | 55 3.90            | —                 | 3.90        | -0.13          | 22 46.87             | —                  | 46.87       | +0.05 |
| $\alpha_1$           |                    |                   |             | 183° 55' 3.77" | $\delta_1$           |                    |             |       |
| Date of Observation, |                    |                   |             | 1875.4         | Date of Observation, |                    |             |       |
| $\mu$                |                    |                   |             | ?              | $\mu'$               |                    |             |       |
|                      |                    |                   |             |                | ?                    |                    |             |       |

## STAR 14.

| Plate.                      | Right Ascension.   |                   |             |                             | Declination.       |                    |             |       |
|-----------------------------|--------------------|-------------------|-------------|-----------------------------|--------------------|--------------------|-------------|-------|
|                             | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $z$ .                       | At Epoch of Plate. | Corr. for $\mu'$ . | Epoch 1875. | $z$ . |
| I                           | 184° 3' 18.34      | —0.16             | 18.18       | —0.05                       | 26° 32' 23.83      | +0.04              | 23.87       | 0.00  |
| II                          | 3 18.34            | —0.16             | 18.18       | —0.05                       | 32 23.87           | +0.04              | 23.91       | —0.04 |
| III                         | 3 18.36            | —0.16             | 18.20       | —0.07                       | 32 23.78           | +0.04              | 23.82       | +0.05 |
| IV                          | 3 17.94            | +0.01             | 17.95       | +0.18                       | 32 23.80           | .00                | 23.80       | +0.07 |
| V                           | 3 18.02            | +0.01             | 18.03       | +0.10                       | 32 23.88           | .00                | 23.88       | —0.01 |
| VI                          | 3 18.21            | +0.01             | 18.22       | —0.09                       | 32 23.82           | .00                | 23.82       | +0.05 |
| VII                         | 3 18.18            | +0.01             | 18.19       | —0.06                       | 32 23.90           | .00                | 23.90       | —0.03 |
| VIII                        | 3 18.00            | +0.01             | 18.01       | +0.12                       | 32 23.80           | .00                | 23.80       | +0.07 |
| IX                          | 3 18.16            | +0.05             | 18.21       | —0.08                       | 32 23.89           | —0.01              | 23.88       | —0.01 |
| X                           | 3 18.06            | +0.05             | 18.11       | +0.02                       | 32 23.93           | —0.01              | 23.92       | —0.05 |
| XI                          | 3 18.08            | +0.05             | 18.13       | .00                         | 32 23.90           | —0.01              | 23.89       | —0.02 |
| XII                         | 3 18.08            | +0.05             | 18.13       | .00                         | 32 23.88           | —0.01              | 23.87       | .00   |
| XIII                        | 3 18.16            | +0.05             | 18.21       | —0.08                       | 32 23.88           | —0.01              | 23.87       | .00   |
| XIV                         | 3 18.08            | +0.05             | 18.13       | .00                         | 32 23.97           | —0.01              | 23.96       | —0.09 |
| Chase                       | 3 17.62            | +0.56             | 18.18       | —0.05                       | 32 24.01           | —0.15              | 23.86       | +0.01 |
| $\alpha_1$ 181° 3' 18.13    |                    |                   |             | $\delta_1$ 26° 32' 23.87    |                    |                    |             |       |
| Date of Observation, 1874.7 |                    |                   |             | Date of Observation, 1874.7 |                    |                    |             |       |
| $\mu$ —0.034 $\pm$ 0.0031   |                    |                   |             | $\mu'$ +0.009 $\pm$ 0.0017  |                    |                    |             |       |

## STAR 15.

| Plate.                      | Right Ascension.   |                   |             |                             | Declination.       |                    |             |       |
|-----------------------------|--------------------|-------------------|-------------|-----------------------------|--------------------|--------------------|-------------|-------|
|                             | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $z$ .                       | At Epoch of Plate. | Corr. for $\mu'$ . | Epoch 1875. | $z$ . |
| I                           | 184° 3' 34.55      | —0.13             | 34.42       | +0.23                       | 26° 31' 20.38      | —0.03              | 20.35       | +0.07 |
| II                          | 3 34.87            | —0.13             | 34.74       | —0.09                       | 31 20.37           | —0.03              | 20.34       | +0.08 |
| III                         | 3 34.69            | —0.13             | 34.56       | +0.09                       | 31 20.43           | —0.03              | 20.40       | +0.02 |
| IV                          | 3 34.68            | +0.01             | 34.69       | —0.04                       | 31 20.52           | .00                | 20.52       | —0.10 |
| V                           | 3 34.85            | +0.01             | 34.86       | —0.21                       | 31 20.45           | .00                | 20.45       | —0.03 |
| VI                          | 3 34.72            | +0.01             | 34.73       | —0.08                       | 31 20.43           | .00                | 20.43       | —0.01 |
| VII                         | 3 34.54            | +0.01             | 34.55       | +0.10                       | 31 20.34           | .00                | 20.34       | +0.08 |
| VIII                        | 3 34.97            | +0.01             | 34.98       | —0.33                       | 31 20.44           | .00                | 20.44       | —0.02 |
| IX                          | 3 34.71            | +0.04             | 34.75       | —0.10                       | 31 20.37           | +0.01              | 20.38       | +0.04 |
| X                           | 3 34.53            | +0.04             | 34.57       | +0.08                       | 31 20.31           | +0.01              | 20.32       | +0.10 |
| XI                          | 3 34.58            | +0.04             | 34.62       | +0.03                       | 31 20.61           | +0.01              | 20.62       | —0.20 |
| XII                         | 3 34.49            | +0.04             | 34.53       | +0.12                       | 31 20.47           | +0.01              | 20.48       | —0.06 |
| XIII                        | 3 34.61            | +0.04             | 34.65       | .00                         | 31 20.37           | +0.01              | 20.38       | +0.04 |
| XIV                         | 3 34.37            | +0.04             | 34.41       | +0.24                       | 31 20.43           | +0.01              | 20.44       | —0.02 |
| Chase                       | 3 34.14            | +0.46             | 34.60       | +0.05                       | 31 20.23           | +0.12              | 20.35       | +0.07 |
| $\alpha_1$ 181° 3' 34.65    |                    |                   |             | $\delta_1$ 26° 31' 20.42    |                    |                    |             |       |
| Date of Observation, 1874.7 |                    |                   |             | Date of Observation, 1874.7 |                    |                    |             |       |
| $\mu$ —0.028 $\pm$ 0.0058   |                    |                   |             | $\mu'$ —0.007 $\pm$ 0.0031  |                    |                    |             |       |



## STAR 16.

| Plate.               | Right Ascension.   |                   |             |                | Declination.         |                    |             |       |
|----------------------|--------------------|-------------------|-------------|----------------|----------------------|--------------------|-------------|-------|
|                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ .          | At Epoch of Plate.   | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| VI                   | 184° 4' 25".98     | +0.02             | 26.00       | -0.10          | 27° 18' 57".12       | +0.01              | 57.13       | +0.12 |
| VIII                 | 4 25.77            | +0.02             | 25.79       | +0.11          | 18 57.35             | +0.01              | 57.36       | -0.11 |
| Chase                | 4 24.98            | +0.02             | 25.90       | .00            | 18 56.91             | +0.34              | 57.25       | .00   |
| $a_1$                |                    |                   |             | 184° 4' 25".90 | $\delta_1$           |                    |             |       |
| Date of Observation, |                    |                   |             | 1875.4         | Date of Observation, |                    |             |       |
| $\mu$                |                    |                   |             | [-0.056]       | $\mu'$               |                    |             |       |
|                      |                    |                   |             |                | [ -0.020 ]           |                    |             |       |

## STAR 17.

| Plate.               | Right Ascension.   |                   |             |               | Declination.         |                    |             |       |
|----------------------|--------------------|-------------------|-------------|---------------|----------------------|--------------------|-------------|-------|
|                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ .         | At Epoch of Plate.   | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| IV                   | 184° 6' 7".06      | —                 | 7.06        | +0.12         | 26° 30' 1.31         | —                  | 1.31        | +0.07 |
| VII                  | 6 7.31             | —                 | 7.31        | -0.13         | 30 1.45              | —                  | 1.45        | -0.07 |
| $a_1$                |                    |                   |             | 184° 6' 7".18 | $\delta_1$           |                    |             |       |
| Date of Observation, |                    |                   |             | 1875.4        | Date of Observation, |                    |             |       |
| $\mu$                |                    |                   |             | ?             | $\mu'$               |                    |             |       |
|                      |                    |                   |             |               | ?                    |                    |             |       |

## STAR 18.

| Plate.               | Right Ascension.   |                   |             |                 | Declination.         |                    |             |       |
|----------------------|--------------------|-------------------|-------------|-----------------|----------------------|--------------------|-------------|-------|
|                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ .           | At Epoch of Plate.   | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| II                   | 184° 12' 53".28    | —                 | 53.28       | -0.18           | 26° 32' 42".56       | —                  | 42.56       | -0.02 |
| IV                   | 12 53.31           | —                 | 53.31       | -0.21           | 32 42.59             | —                  | 42.59       | -0.05 |
| V                    | 12 53.20           | —                 | 53.20       | -0.10           | 32 42.48             | —                  | 42.48       | +0.06 |
| VI                   | 12 53.21           | —                 | 53.21       | -0.11           | 32 42.52             | —                  | 42.52       | +0.02 |
| VII                  | 12 52.51           | —                 | 52.51       | +0.59           | 32 42.41             | —                  | 42.41       | +0.13 |
| VIII                 | 12 53.58           | —                 | 53.58       | -0.48           | 32 42.66             | —                  | 42.66       | -0.12 |
| X                    | 12 53.15           | —                 | 53.15       | -0.05           | 32 42.37             | —                  | 42.37       | +0.17 |
| XI                   | 12 53.01           | —                 | 53.01       | +0.09           | 32 42.61             | —                  | 42.61       | -0.07 |
| XII                  | 12 52.78           | —                 | 52.78       | +0.32           | 32 42.68             | —                  | 42.68       | -0.14 |
| XIV                  | 12 52.96           | —                 | 52.96       | +0.14           | 32 42.49             | —                  | 42.49       | +0.05 |
| $a_1$                |                    |                   |             | 184° 12' 53".10 | $\delta_1$           |                    |             |       |
| Date of Observation, |                    |                   |             | 1875.3          | Date of Observation, |                    |             |       |
| $\mu$                |                    |                   |             | ?               | $\mu'$               |                    |             |       |
|                      |                    |                   |             |                 | ?                    |                    |             |       |

## STAR 19.

| Plate.               | Right Ascension.   |                   |             |                | Declination.         |                    |             |       |
|----------------------|--------------------|-------------------|-------------|----------------|----------------------|--------------------|-------------|-------|
|                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ .          | At Epoch of Plate.   | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| II                   | 184° 18' 12.71     | —                 | 12.71       | —0.11          | 27° 15' 32.59        | —                  | 32.59       | +0.16 |
| V                    | 18 12.48           | —                 | 12.48       | +0.12          | 15 32.77             | —                  | 32.77       | —0.02 |
| VI                   | 18 12.70           | —                 | 12.70       | —0.10          | 15 32.72             | —                  | 32.72       | +0.03 |
| VIII                 | 18 12.50           | —                 | 12.50       | +0.10          | 15 32.92             | —                  | 32.92       | —0.17 |
| $\alpha_1$           |                    |                   |             | 184° 18' 12.60 | $\delta_1$           |                    |             |       |
| Date of Observation, |                    |                   |             | 1874.1         | Date of Observation, |                    |             |       |
| $\mu$                |                    |                   |             | ?              | $\mu'$               |                    |             |       |

## STAR 20.

| Plate.               | Right Ascension.   |                   |             |                | Declination.         |                    |             |       |
|----------------------|--------------------|-------------------|-------------|----------------|----------------------|--------------------|-------------|-------|
|                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ .          | At Epoch of Plate.   | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| VIII                 | 184° 21' 14.09     | —                 | 14.09       | —              | 27° 17' 43.58        | —                  | 43.58       | —     |
| $\alpha_1$           |                    |                   |             | 184° 21' 14.09 | $\delta_1$           |                    |             |       |
| Date of Observation, |                    |                   |             | 1875.4         | Date of Observation, |                    |             |       |
| $\mu$                |                    |                   |             | ?              | $\mu'$               |                    |             |       |

## STAR 21.

| Plate.                      | Right Ascension.   |                   |             |       | Declination.                |                    |             |       |
|-----------------------------|--------------------|-------------------|-------------|-------|-----------------------------|--------------------|-------------|-------|
|                             | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ . | At Epoch of Plate.          | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| I                           | 184° 26' 44."13    | —0.24             | 43.89       | +0.05 | 26° 32' 42."76              | 0.00               | 42.76       | +0.05 |
| II                          | 26 44.24           | —0.24             | 44.00       | —0.06 | 32 42.74                    | .00                | 42.74       | +0.07 |
| III                         | 26 44.15           | —0.24             | 43.91       | +0.03 | 32 42.79                    | .00                | 42.79       | +0.02 |
| IV                          | 26 44.17           | +0.02             | 44.19       | —0.25 | 32 42.87                    | .00                | 42.87       | —0.06 |
| V                           | 26 44.03           | +0.02             | 44.05       | —0.11 | 32 42.81                    | .00                | 42.81       | .00   |
| VI                          | 26 43.80           | +0.02             | 43.82       | +0.12 | 32 42.85                    | .00                | 42.85       | —0.04 |
| VII                         | 26 43.77           | +0.02             | 43.79       | +0.15 | 32 42.76                    | .00                | 42.76       | +0.05 |
| VIII                        | 26 43.94           | +0.02             | 43.96       | —0.02 | 32 42.93                    | .00                | 42.93       | —0.12 |
| IX                          | 26 43.77           | +0.07             | 43.84       | +0.10 | 32 42.74                    | .00                | 42.74       | +0.07 |
| X                           | 26 43.82           | +0.07             | 43.89       | +0.05 | 32 42.86                    | .00                | 42.86       | —0.05 |
| XI                          | 26 43.90           | +0.07             | 43.97       | —0.03 | 32 42.80                    | .00                | 42.80       | +0.01 |
| XII                         | 26 43.93           | +0.07             | 44.00       | —0.06 | 32 42.90                    | .00                | 42.90       | —0.09 |
| XIII                        | 26 43.80           | +0.07             | 43.87       | +0.07 | 32 42.77                    | .00                | 42.77       | +0.04 |
| XIV                         | 26 43.85           | +0.07             | 43.92       | +0.02 | 32 42.75                    | .00                | 42.75       | +0.06 |
| Chase                       | 26 43.09           | +0.85             | 43.94       | .00   | 32 42.75                    | +0.02              | 42.77       | +0.04 |
| $\alpha_1$ 184° 26' 43.94   |                    |                   |             |       | $\delta_1$ 26° 32' 42.81    |                    |             |       |
| Date of Observation, 1874.7 |                    |                   |             |       | Date of Observation, 1874.7 |                    |             |       |
| $\mu$ —0.051 $\pm$ 0.0038   |                    |                   |             |       | $\mu'$ —0.001 $\pm$ 0.0023  |                    |             |       |

## STAR 22.

| Plate.                      | Right Ascension.   |                   |             |       | Declination.                |                    |             |       |
|-----------------------------|--------------------|-------------------|-------------|-------|-----------------------------|--------------------|-------------|-------|
|                             | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ . | At Epoch of Plate.          | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| I                           | 184° 30' 29."08    | —0.19             | 28.89       | —0.03 | 26° 47' 33."51              | +0.03              | 33.54       | +0.10 |
| II                          | 30 29.16           | —0.19             | 28.97       | —0.11 | 47 33.60                    | +0.03              | 33.63       | +0.01 |
| III                         | 30 29.06           | —0.19             | 28.87       | —0.01 | 47 33.69                    | +0.03              | 33.72       | —0.08 |
| IV                          | 30 28.69           | +0.02             | 28.71       | +0.15 | 47 33.62                    | .00                | 33.62       | +0.02 |
| V                           | 30 28.70           | +0.02             | 28.72       | +0.14 | 47 33.54                    | .00                | 33.54       | +0.10 |
| VI                          | 30 28.84           | +0.02             | 28.86       | .00   | 47 33.72                    | .00                | 33.72       | —0.08 |
| VII                         | 30 29.01           | +0.02             | 29.03       | —0.17 | 47 33.78                    | .00                | 33.78       | —0.14 |
| VIII                        | 30 28.73           | +0.02             | 28.75       | +0.11 | 47 33.61                    | .00                | 33.61       | +0.03 |
| IX                          | 30 28.75           | +0.06             | 28.81       | +0.05 | 47 33.63                    | —0.01              | 33.62       | +0.02 |
| X                           | 30 28.88           | +0.06             | 28.94       | —0.08 | 47 33.62                    | —0.01              | 33.61       | +0.03 |
| XI                          | 30 28.79           | +0.06             | 28.85       | +0.01 | 47 33.67                    | —0.01              | 33.66       | —0.02 |
| XII                         | 30 28.78           | +0.06             | 28.84       | +0.02 | 47 33.56                    | —0.01              | 33.55       | +0.09 |
| XIII                        | 30 28.83           | +0.06             | 28.89       | —0.03 | 47 33.69                    | —0.01              | 33.68       | —0.04 |
| XIV                         | 30 28.87           | +0.06             | 28.93       | —0.07 | 47 33.67                    | —0.01              | 33.66       | —0.02 |
| Chase                       | 30 28.21           | +0.68             | 28.89       | —0.03 | 47 33.75                    | —0.12              | 33.63       | +0.01 |
| $\alpha_1$ 184° 30' 28.86   |                    |                   |             |       | $\delta_1$ 26° 47' 33.64    |                    |             |       |
| Date of Observation, 1874.7 |                    |                   |             |       | Date of Observation, 1874.7 |                    |             |       |
| $\mu$ —0.041 $\pm$ 0.0034   |                    |                   |             |       | $\mu'$ +0.007 $\pm$ 0.0026  |                    |             |       |

## STAR 23.

| Plate.               | Right Ascension.   |                   |             |                 | Declination.         |                    |             |       |
|----------------------|--------------------|-------------------|-------------|-----------------|----------------------|--------------------|-------------|-------|
|                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ .           | At Epoch of Plate.   | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| I                    | 184° 32' 38.57"    | —0.23             | 38.34       | +0.11           | 26° 16' 36.20"       | +0.01              | 36.21       | +0.07 |
| II                   | 32 38.55           | —0.23             | 38.32       | +0.13           | 16 36.20             | +0.01              | 36.21       | +0.07 |
| III                  | 32 38.63           | —0.23             | 38.40       | +0.05           | 16 36.14             | +0.01              | 36.15       | +0.13 |
| IV                   | 32 38.53           | +0.02             | 38.55       | —0.10           | 16 36.33             | .00                | 36.33       | —0.05 |
| V                    | 32 38.65           | +0.02             | 38.67       | —0.22           | 16 36.40             | .00                | 36.40       | —0.12 |
| VI                   | 32 38.38           | +0.02             | 38.40       | +0.05           | 16 36.28             | .00                | 36.28       | .00   |
| VII                  | 32 38.31           | +0.02             | 38.33       | +0.12           | 16 36.16             | .00                | 36.16       | +0.12 |
| VIII                 | 32 38.55           | +0.02             | 38.57       | —0.12           | 16 36.29             | .00                | 36.29       | —0.01 |
| IX                   | 32 38.33           | +0.07             | 38.40       | +0.05           | 16 36.32             | .00                | 36.32       | —0.04 |
| X                    | 32 38.39           | +0.07             | 38.46       | —0.01           | 16 36.36             | .00                | 36.36       | —0.08 |
| XI                   | 32 38.35           | +0.07             | 38.42       | +0.03           | 16 36.32             | .00                | 36.32       | —0.04 |
| XII                  | 32 38.49           | +0.07             | 38.56       | —0.11           | 16 36.35             | .00                | 36.35       | —0.07 |
| XIII                 | 32 38.31           | +0.07             | 38.38       | +0.07           | 16 36.24             | .00                | 36.24       | +0.04 |
| XIV                  | 32 38.46           | +0.07             | 38.53       | —0.08           | 16 36.24             | .00                | 36.24       | +0.04 |
| Chase                | 32 37.57           | +0.80             | 38.37       | +0.08           | 16 36.21             | —0.03              | 36.18       | +0.10 |
| $a_1$                |                    |                   |             | 184° 32' 38.45  | $\delta_1$           |                    |             |       |
| Date of Observation, |                    |                   |             | 1874.7          | Date of Observation, |                    |             |       |
| $\mu$                |                    |                   |             | —0.048 ± 0.0040 | $\mu'$               |                    |             |       |
|                      |                    |                   |             |                 | +0.002 ± 0.0030      |                    |             |       |

## STAR 24.

| Plate.               | Right Ascension.   |                   |             |                 | Declination.         |                    |             |       |
|----------------------|--------------------|-------------------|-------------|-----------------|----------------------|--------------------|-------------|-------|
|                      | At Epoch of Plate. | Corr. for $\mu$ . | Epoch 1875. | $v$ .           | At Epoch of Plate.   | Corr. for $\mu'$ . | Epoch 1875. | $v$ . |
| I                    | 184° 41' 35.82"    | —0.35             | 35.47       | +0.06           | 26° 15' 18.80"       | +0.08              | 18.88       | —0.04 |
| II                   | 41 35.90           | —0.35             | 35.55       | —0.02           | 15 18.73             | +0.08              | 18.81       | +0.03 |
| III                  | 41 35.87           | —0.35             | 35.52       | +0.01           | 15 18.75             | +0.08              | 18.83       | +0.01 |
| IV                   | 41 35.74           | +0.03             | 35.77       | —0.24           | 15 18.72             | —0.01              | 18.71       | +0.13 |
| V                    | 41 35.68           | +0.03             | 35.71       | —0.18           | 15 18.87             | —0.01              | 18.86       | —0.02 |
| VI                   | 41 35.60           | +0.03             | 35.63       | —0.10           | 15 18.72             | —0.01              | 18.71       | +0.13 |
| VII                  | 41 35.35           | +0.03             | 35.38       | +0.15           | 15 18.89             | —0.01              | 18.88       | —0.04 |
| VIII                 | 41 35.49           | +0.03             | 35.52       | +0.01           | 15 19.00             | —0.01              | 18.99       | —0.15 |
| IX                   | 41 35.16           | +0.10             | 35.26       | +0.27           | 15 18.90             | —0.03              | 18.87       | —0.03 |
| X                    | 41 35.45           | +0.10             | 35.55       | —0.02           | 15 18.87             | —0.03              | 18.84       | .00   |
| XI                   | 41 35.41           | +0.10             | 35.51       | +0.02           | 15 18.86             | —0.03              | 18.83       | +0.01 |
| XII                  | 41 35.41           | +0.10             | 35.51       | +0.02           | 15 18.91             | —0.03              | 18.88       | —0.04 |
| XIII                 | 41 35.39           | +0.10             | 35.49       | +0.04           | 15 18.78             | —0.03              | 18.75       | +0.09 |
| XIV                  | 41 35.42           | +0.10             | 35.52       | +0.01           | 15 18.90             | —0.03              | 18.87       | —0.03 |
| $a_1$                |                    |                   |             | 184° 41' 35.53  | $\delta_1$           |                    |             |       |
| Date of Observation, |                    |                   |             | 1874.7          | Date of Observation, |                    |             |       |
| $\mu$                |                    |                   |             | —0.075 ± 0.0099 | $\mu'$               |                    |             |       |
|                      |                    |                   |             |                 | +0.018 ± 0.0059      |                    |             |       |

**Catalogue of Results.**—In the “CATALOGUE OF STARS” on p. 477 are collected the final positions and proper motions deduced by me from the Rutherford Plates. The right ascensions and declinations are obtained from the  $\alpha_1$  and  $\delta_1$  given on the preceding pages by means of the formulæ

$$\alpha = \alpha_1 + T_\alpha, \quad \delta = \delta_1 + T_\delta,$$

$T_\alpha$  and  $T_\delta$  being the transformation corrections. The columns are as follows :

- 1 gives my Number of the star ;
- 2 gives Chase's Number ;
- 3 gives the B. D. Number, and 4 the Magnitude of the star in that catalogue ;
- 5 gives the Right Ascension for 1875 in degrees, minutes, and seconds of arc, reduced to the mean epoch *using the value of the proper motion* given in column 6.
- 7 and 8 give the corresponding quantities for the Declinations ;
- 9 gives the Mean Date of Observation ; and
- 10 gives the Number of Plates on which the position depends.

It may be well to repeat here that the probable error of a single observation is

$$r_\alpha = \pm 0''.0939, \quad r_\delta = \pm 0''.0595,$$

and of a position depending on fourteen plates

$$r_\alpha = \pm 0''.025, \quad r_\delta = \pm 0''.016.$$

## Catalogue of 24 Stars of the Cluster in Coma Berenices.

Mean Equinox of 1875.0.

Epoch 1875.0.

| No. | Chase's<br>No. | B. D. No. | B. D.<br>Mag.    | Right Ascen.<br>1875.0 | Proper Mot.<br>in R. A. | Declination<br>1875.0. | Proper Mot.<br>in Decl. | Mean Date<br>of Observat. | No. of Plates<br>used. |
|-----|----------------|-----------|------------------|------------------------|-------------------------|------------------------|-------------------------|---------------------------|------------------------|
| 1   | 2              | 26.2324   | 7.3              | 183° 5' 42.93          | —0.070                  | 26 52 58.29            | +0.073                  | 1875.1                    | 13                     |
| 2   | 3              | 26.2326   | 6.6              | 10 56.03               | —0.039                  | 26 42 10.58            | +0.008                  | 1875.1                    | 13                     |
| 3   | 4              | 25.2487   | 7.5              | 14 16.86               | [+0.011]                | 25 45 17.90            | [+0.021]                | 1875.4                    | 1                      |
| 4   | 5              | 26.2329   | 6.3              | 30 16.92               | —0.181                  | 26 41 42.87            | +0.036                  | 1874.7                    | 14                     |
| 5   | 6              | 27.2114   | 5.0              | 30 31.99               | —0.090                  | 27 19 2.21             | +0.096                  | 1871.7                    | 14                     |
| 6   |                | 26.2330   | 8.9              | 36 57.60               | —0.064                  | 26 27 36.29            | +0.004                  | 1874.6                    | 13                     |
| 7   | 8              | 26.2331   | 8.3              | 38 52.08               | —0.025                  | 26 37 14.60            | —0.004                  | 1874.7                    | 14                     |
| 8   | 9              | 26.2332   | 8.2              | 41 48.91               | —0.057                  | 26 24 53.58            | —0.020                  | 1874.7                    | 14                     |
| 9   | 10             | 25.2493   | 7.2              | 41 53.47               | —0.289                  | 25 43 14.55            | +0.133                  | 1874.7                    | 14                     |
| 10  | 11             | 25.2495   | 7.5              | 47 15.64               | —0.039                  | 25 41 28.22            | —0.014                  | 1874.7                    | 14                     |
| 11  | 12             | 27.2116   | 8.0              | 51 46.01               | [—0.042]                | 27 18 7.43             | [+0.013]                | 1875.4                    | 3                      |
| 12  |                | 27.2117   | 8.9              | 52 58.26               | —                       | 27 14 34.99            | —                       | 1875.4                    | 3                      |
| 13  |                | 26.2336   | 9.0              | 183 55 4.46            | —                       | 26 22 46.69            | —                       | 1875.4                    | 4                      |
| 14  | d              | 26.2337   | 5.0 <sup>1</sup> | 3 18.13                | —0.034                  | 26 32 23.87            | +0.009                  | 1874.7                    | 14                     |
| 15  | 14             | 26.2338   | 8.5              | 3 34.65                | —0.028                  | 26 31 20.42            | —0.007                  | 1874.7                    | 14                     |
| 16  | 15             | 27.2118   | 7.8              | 4 20.37                | [—0.056]                | 27 18 51.07            | [—0.020]                | 1875.4                    | 2                      |
| 17  |                | 26.2339   | 9.1              | 6 7.12                 | —                       | 26 30 1.35             | —                       | 1875.4                    | 2                      |
| 18  |                | 26.2340   | 8.6              | 12 53.13               | —                       | 26 32 42.22            | —                       | 1875.3                    | 10                     |
| 19  |                | 26.2340   | 8.8              | 18 18.24               | —                       | 27 15 31.81            | —                       | 1874.1                    | 4                      |
| 20  |                | 27.2120   | 8.8              | 21 21.23               | —                       | 27 17 42.26            | —                       | 1875.4                    | 4                      |
| 21  | 18             | 26.2341   | 9.0              | 21 21.23               | —                       | 26 32 40.89            | —0.001                  | 1874.7                    | 1                      |
| 22  | 19             | 26.2343   | 7.0              | 26 43.99               | —0.051                  | 26 32 40.89            | —0.007                  | 1874.7                    | 14                     |
| 23  | 20             | 26.2344   | 5.3 <sup>1</sup> | 30 32.43               | —0.041                  | 26 47 31.03            | +0.007                  | 1874.7                    | 14                     |
| 24  |                | 26.2345   | 6.3              | 32 34.39               | —0.048                  | 26 16 33.32            | +0.002                  | 1874.7                    | 14                     |
|     |                | 26.2347   | 8.3              | 41 29.75               | —0.075                  | 26 15 13.79            | +0.018                  | 1874.7                    | 14                     |

<sup>1</sup> May be variable. Cf. Köhl in Astr. Soc. of the Pacific, Publications, Vol. X, no. 60, p. 24.



On the foregoing pages have been recorded the measures and methods of reduction leading to the "CATALOGUE OF STARS," p. 477. In general it will be better to measure a large number of plates with less elaboration than has been done in the present case. But owing to the very small number of existing photographs of so early a date it was necessary, in order to get the best results, to employ all possible precaution to guard against errors. The excellent agreement between Chase's determinations and the photographic positions speaks well for the accuracy of both researches. The proper motions cannot, of course, be verified until a later date, but it seems safe to assume that all of those depending on fourteen plates and on Chase's observations are very nearly correct. It is to be regretted that their number is not larger. The group is not well adapted to photographic work, however. The range of magnitudes is large and the stars are very scattered. In fact, it may be doubted whether the term Group may properly be applied to these stars. The proper motions certainly do not indicate any physical connection. This matter, however, is of ulterior interest.

In conclusion, I wish again to thank Messrs. Schlesinger and Hays for aiding me in measuring the plates; Dr. Davis for invaluable assistance in the catalogue work, and for freely placing at my disposal his experience in all matters connected therewith; Professor Jacoby for his ever-ready counsel on all difficult points, and Professor Rees, Director of the Observatory, for the interest he has shown in the work, and for securing its publication. It may also be mentioned that free use has been made of the Observatory Contributions, especially of Dr. Davis' "Fifty-Six Stars" and of Dr. Schlesinger's "Præsepe."

## VITA.

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Walter Coluzzi Kretz was born in Bavaria, Germany, August the 20th, 1878. Arriving at the United States of America in 1880, he was educated there, chiefly at home, until he entered the School of Arts of Columbia University in October, 1892. In his career at this institution, he received Honors in Mathematics and in Modern Languages. Graduating as Bachelor of Arts in 1896, with Final Honors in Mathematics, he continued his studies in the School of Pure Science of Columbia University, working chiefly in the Departments of Astronomy, Mathematics and Mechanics. He was University Scholar in Astronomy in the years 1896-1897, and 1897-1898, and University Fellow in 1898-1899. In the spring of 1897 he received the degree of Master of Arts, and in 1899 that of Doctor of Philosophy.









